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Adequacy, Equity and Fundamental Dominance: Unanimous and Comparable Allocations in Rational Social Choice, with Applications to Marriage and Wages

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Summary.

This paper contributes to the "network" and "reflective equilibrium" approach to social choice in considering three related and important allocative criteria,their relations to other criteria, and a number of applications. In adequate allocations, each individual's lot would not be better attributed to any other individual. In equitable allocations, it is not better that any individual receive the lot of any other rather than his own.Finally, fundamental dominance results from unanimity plus impartiality (non-discrimination). These criteria have different deep meanings and differents scopes of applicability and of existence. Yet, they are linked by specific strong relations. The set of these criteria is thus more meaningful and of wider relevance than if each one were considered by itself. These properties also have essential relations with market equilibria or stability (cores) in many important situations. A number of applications are discussed, concerning the ethic of distribution and of freedom, assignment allocations, the theory of matching markets and in particular of marriage, "Tinbergen-equitable" wages and wage-price rigidities, etc.

1 - Introduction.

Social choice has often focussed on "consistency rationality", i.e., the existence of a social ordering, while it is more basic that it systematically abides by "cognitive rationality", i.e., consistent and optimal use of all relevant information (about both facts and ethics). Rational social choice --like rationality in any complex decision problem-- thus results from what John Rawls aptly calls "considered judgement in reflective equilibrium". This implies several things: (1) Use of principles or criteria, which are more or less general (be they "scientific laws" or moral rules or principles or "maxims", in particular application of the "generalization principle" of meta-ethics, or even "rules of thumb", norms or traditions). (2) For each principle, evaluative consideration back and forth between its general formulation and its applied consequences until "equilibrium" is reached (this is Rawls'use of the expression, for determining principles of social ethics). (3) For each principle, evaluative consideration of all its aspects, meanings, requirements, implications and applications, domains of meaningfulness, of relevance, of acceptability, of decisiveness. (4) Use of several criteria: this is what characterizes a "complex" choice situation. (5) Analysis of the relations between the criteria, in particular the logical relations: is their set inconsistent (as with Arrow's five social choice criteria), or on the contrary do they surprisingly imply each other, are they unexpectedly equivalent, so that their different formulations enrich their meaningfulness (as the comparisons of inequalities in Kolm, 1966,1976,1977); are they complementary in specifying the choice; or does one imply the other so that the former is a specification of the latter and the latter can be taken as an extension of an interesting former one beyond its domain of applicability[1]? This summarizes (correctly, I think) the general present state of thinking on the rational method of social choice, social ethics or "justice", a method which has been called, with various emphases, network (of critera) analysis (Edel), the multi-principle approach (Leventhal, Mikula, Schwinger), the coherence theory (Brandt), reflective equilibrium (Rawls), the "analytico-dialectical" conception (Weinberger), the method of "prima facie obligations" (Ross), "moral polyarchy" (Gallie), "la justice comme justesse" (Kolm), and is also

endorsed by modern "ethicists" such as C.F. Delaney, Stuart Hampshire, Norman Daniels, Jane English, Kai Nielsen among others. The great Isaiah Berlin speaks of "social morality... as a system of coherent - i.e., not internally contradictory (and, according to some moralists, mutually entailing) sets of rules" and goes as far as commenting "a part of what we mean by rationality is the art of applying, and combining, reconciling, choosing among general principles in a manner for which complete theoretical explanation (or justification) can never, in principle, be given"(2). Rational social choice is important both because it feeds one's reflexion about how things should be, and for explaining how things are since it influences individual and collective (social, institutional, political) behavior.

This paper contributes to this consistent or network approach for the allocation of resources. It considers a partial, integrated network of criteria consisting of a core of three different, but closely related, important criteria, "adequacy", "equity" and "fundamental dominance", and of other more or less classical or specific ones such as freedom of choice and of exchange, unanimity and Pareto-efficiency, "fundamental efficiency", non-discrimination and impartiality, equality of opportunity, the social welfare function, wealth or income or surplus or output maximization or cost minimization, stability of exchanges or matchings, non-jealousy and non-envy, "Tinbergen-equitable wages", "full-payment equity", "monotone sharing", etc. We will consider the meanings and relevance of these interfering or related criteria, their properties of possibility, existence and uniqueness, and their relations of inclusion or implication and specification or extension.

We consider assignments of "lots" to "individuals". In the various applications, these terms can have many meanings. For instance "individuals" can be physical individuals or other agents or groups or institutions (firms, branches, bureaux, families, nations, etc.), and "lots" can be consumption of goods or services, properties, locations, jobs, job-wage pairs, mates, etc. Roughly speaking (precision will come below), the three basic properties and their relations are as follows.

The allocation is adequate when no individual lot would better

be somebody else's lot. The allocation is equitable if it is not better that any individual receive the lot of any other rather than his own. For adequacy to be meaningful we only need any criterion for judging to whom a lot is better attributed, and such a criterion is implied and required by any general allocative judgement. As for this "equity", it has a meaning which is by now classical when the defining judgement is according to the individual's preference (no one prefers any other's lot to his own[3]).

An allocation can be adequate and unequitable, or equitable but inadequate, as the examples of section 2 will show. It can also be both adequate and equitable. But how should we assign given lots to given individuals if one assignment is adequate (and unequitable) and another one is equitable (and inadequate)? We shall see that such a dilemma cannot arise: adequacy and equity are different but necessarily non-competing criteria. One example of application, discussed in section 11 below, is a solution of the "paradox of marriage" (or of any other matching problem). Among stable sets of marriages, there is one in which each man marries the woman he prefers among those he can have, and also one in which each woman marries the man she prefers among those she can have; but when each man marries the woman he prefers in this set, then each woman's husband is the man she dislikes the most among possible choices, and symmetrically for men in the case of women's best choice[4]. But on the other hand the mentioned adequacy-equity result implies that in an important case, when each woman marries the man she prefers, each man ipso facto receives his most preferred mate, and reciprocally. The only solution to this apparent contradiction is that, in this case, there is only one stable set of marriages[5].

Fundamental dominance results from two more basic properties. One is unanimity or its equivalent for the considered comparisons of lots for each individual[6]. The other one is "independent impartiality (or anonymity)". It means that in each state of affairs, the labelling or numbering of individuals is irrelevant (or permutations of individuals along with their lots which describe all the relevant aspects of the situation, are irrelevant). That may seem obvious, unavoidable and innocuous, but the specific property which is

introduced is that this re-labelling or permutation can be different in different states which other properties (here unanimity) may compare. Two states which differ from each other only by such a permutation of individuals with their lots are called "permuted states". A state "fundamentally dominates" another one if it is unanimously preferred or equivalent to one of its permuted states. An assignment is "fundamentally dominant" if it fundamentally dominates all other assignments. The relation with equity and adequacy will be that each of these two properties imply fundamental dominance, while fundamental dominance implies each of these two properties if this property can exist. These three properties can also be redefined in considering only a subset of the assignments (for instance only possible ones, or only stable ones in bilateral matching questions), and the mentioned relations between the three properties still hold.

The inter-individual comparisons which are implied by adequacy and by fundamental dominance can be given a number of meanings which are presented in section 4 and include the cases where quantitative outcomes are relevant, more generally the question of ordinal "fundamental preferences" which enable one to compare different tastes the "ethical observer", problems of bidding, problems of bilateral matchings with "fundamentally consistent" sets of individual preferences (e.g., marriage as a public good or "monotone sharing" of the couple's total income).

The second example of application which we consider in detail (after marriage, in section 12) concerns the labor market and wage determination, a crucial domain of interference between free exchange and equity considerations, with questions concerning the ethical quality of the market and the explanation of a number of behavior, non-market interferences and wage rigidities. We in particular consider Tinbergen-equity (i.e., each worker prefers his job-wage pair to that of any other), its possibility and its relations to free exchange.

One interest of the adequacy, equity and fundamental dominance properties and of their relations is that these concepts and results can (but need not) be applied to the allocation of indivisible items, a notoriously difficult problem where a number of classical concepts and

methods fail but which has important applications (assignments of individuals, locations problems, strong increasing returns to scale, etc.).

We may also remark here that this study in particular establishes the links between three domains which had hitherto remained disconnected: equity (fairness, non-envy, equality of opportunity, etc.), the social welfare functional (Pareto-Arrow utilitarian "social choice"(7)) and the theories of matchings and assignments and their applications.

• The paper is organized as follows.Part I provides examples and meanings. Section 2 proposes simple illustrative examples of various situations. Sections 3, 4 and 5 discuss the meanings and scopes of the concepts and of their relations. In part II, section 6 provides the complete definitions and section 7 states the relations which section 8 proves. Section 9 relates these criteria to income or welfare maximization and section 10 shows some properties of fundamental dominance. Finally, in part III sections 11 and 12 show applications of the concepts and results to the economic theory of marriage and more generally of matching markets, and to the properties of "Tinbergen-equitable wages" and causes of wage rigidities.

I - EXAMPLES AND MEANINGS.

2 - Illustrative examples.

Let us assume that a firm has to fill two positions, one for a salesman and one for a steelworker, with two of its employees, Jules and Jim. "Production" in each job means a contribution to the firm's profit, and they are independent of each other. Assume Jules produces 14 at steelwork and 13 at sales, while Jim produces 11 as a steelworker and 12 as a salesman. Then Jules produces more at steelwork than at sales while Jim produces more at sales than at steelwork, so Jules is assigned to steel and Jim is assigned to sales. Assume now that Jules produces 14 as a steelworker and 11 as a salesman, while Jim produces 13 at steelwork and 12 when he sells. Then while Jules still produces more at steelwork than at sales, Jim does too now. But Jules produces

more at steelwork than Jim does, while Jim produces more at sales than Jules does: steelwork is more efficiently handled by Jules than by Jim, and the reverse holds for sales. Thus again Jules is assigned to steel and Jim becomes the salesman, but now it is for a different intermediary rationale (the ultimate rationale still being the firms's maximal profit). This second rationale is not operative in the former case since, then, Jules produced more than Jim both at steelwork (14 against 11) and at sales (13 against 12). Consider now a third case, in which Jules produces 12 at steelwork and 11 at sales, while Jim produces 11 at steelwork and 12 at sales. Then both rationales justify assigning Jules to steel and Jim to sales: Jules produces more at steelwork than at sales and than Jim at steelwork, while Jim produces more at sales than Jules does and than he himself produces at steelwork. Finally consider the situation in which Jules produces 12 at steelwork and 13 at sales, and Jim produces 13 at steelwork and 15 at sales. Then assigning Jules to steel and Jim to sales is again the best assignment since it produces 12+15=27 while the reverse assignment produces only 13+13=26. Yet, none of the above rationales works since steelworker Jules is outperformed both by salesman Jules and by steelworker Jim.

This assignment situation and these figures can also have other meanings. For instance, the figures may represent the individuals'earnings in each occupation. It may be that each one earns more in his occupation than he would earn in the other one, or than the other individual would earn in this occupation, or both, or, also, no assignment may have any of these two properties. Alternatively, the figures may measure in "utils" the satisfactions that each job provides for each individual, and it may be satisfaction derived from both performing the job and receiving the corresponding wage. The logic may be similar but it may then acquire another meaning, of ethical nature. We now consider cases of this type, and productivity is assumed to be irrelevant (for example it is no longer the problem; or each employee performs equally well in each job; or, in each job, they each perform equally well; or, if wages can vary according to jobs, to individuals or both, these equalities in each job or of each worker hold for performances which are the contributions to the firm's profit taking these wage costs into account). Then, if Jules values steelworking at

14 and selling at 13, while Jim values selling at 12 and steelworking at 11, in the assignment of steel to Jules and of sales to Jim each one prefers his lot to the other's lot: this is what is classically called equity [8]. If Jules values steelworking at 14 and selling at 11, while Jim values steelworking at 13 and selling at 12, assigning steel to Jules and sales to Jim is no longer "equitable" since Jim prefers steelworking. But it allocates steel to the individual who enjoys it the most (14 against 13), and it also allocates sales to the individual who enjoys it the most (12 against 11). We call such an allocation adequate, a term which we also apply to the corresponding case of the previous paragraph. Notice also that, in the first situation, this assignment is not "adequate" since it allocates sales to Jim who values this job at 12 while Jules values it at 13. But an allocation can also be both equitable and adequate, as is the case with steelworking for Jules and sales for Jim if Jules values steelworking at 12 and selling at 11, while Jim values selling at 12 and steelworking at 11.And it can also be neither equitable nor adequate, as is for example the case of steel for Jules and sales for Jim when Jules values steelworking at 12 and selling at 13, while Jim values steelworking at 13 and whatever may be his valuation of sales (or, alternatively, while Jim values sales at 12 and whatever may be his valuation of steelworking). This is easily verified.

We can also check that in all cases where one assignment is equitable or adequate, the other one is neither equitable nor adequate. Indeed this property is general if the two figures are not the same for at least one individual and at least one job. Obviously, the two alternative assignments cannot then be both equitable or both adequate. But, also, if steel for Jules and sales for Jim were equitable, and sales for Jules and steel for Jim were adequate, the figures would have to satisfy :

Steel for Jules $\geq$ sales for Jules $\geq$ sales for Jim $\geq$ steel for Jim $\geq$ steel for Jules

which is impossible if the four figures are not all equal (and similarly if each assignment had the other property).

We remark that equity and adequacy have one property in common. If steel for Jules and sales for Jim is either equitable or adequate,

then each of the two figures of this assignment is not lower than one of the two figures of the opposite assignment --a different one for each of the first two figures-- (indeed, for equity, steel for Jules ≥ sales for Jules and sales for Jim ≥ steel for Jim, and for adequacy, steel for Jules ≥ steel for Jim and sales for Jim ≥ sales for Jules). These two kinds of dominance are indistinguishable if the ordering of the outcomes (the two figures) in each assignment is irrelevant whatever may be their given ordering in the other assignment (the orderings of the outcomes are "independently irrelevant"). This is, for example, the case when the outcomes are additive contributions to profits, or for "impartial" ethical judgments if this irrelevance defines impartiality. When the outcomes are individuals'utilities and for ethical judgment, this general dominance is the necessary result of unanimity plus this impartiality (and this impartiality is closely linked to the assumed interpersonal comparability of utilities, as will be discussed further below).

When there is any number n of individuals, and for situations which are still relevantly and sufficiently characterized by a figure for each individual (such as, for example, his contribution to profits or his utility level as in the above examples), situation 1 "fundamentally dominates" situation 2 if there is a one-to-one correspondence between the n figures in situation 1 and the n figures in situation 2 such that, in each pair, the situation 2 figure is not larger than the situation 1 figure[9]. In particular consider assignment problems between n individuals and n lots, where allocating a lot to an individual (or the converse) generates such a figure (profit or utility, etc.). Then the assignment is "fundamentally dominant" if it fundamentally dominates all the other assignments. If n=2, we have noticed that both equitable and adequate assignments are fundamentally dominant, and, indeed, any fundamentally dominant assignment is obviously either equitable or adequate. For n≥2, we see easily that any equitable or adequate assignment is fundamentally dominant (compare the "individual plus lot" pairs with the same individual in the case of equity, and with the same lot in the case of adequacy). But with n>2, an assignment can be fundamentally dominant without being either equitable or adequate. This is the case, for example, if we add a third individual, Jane, and a third job, say

supervision, if the relevant figures produced by each individual in each job (such as independent contribution to profit or the individual's utility) are the ones given by the matrix of table 1.

	steelwork	sales	supervision
Jules	11	12	10
Jim	10	13	10
Jane	10	14	15

Table 1

Indeed, among the six possible assignments, assigning steel to Jules, sales to Jim and supervision to Jane fundamentally dominates each of the five other ones since it yields (11,13,15) while the other ones respectively yield (11,14,10) (steel to Jules, sales to Jane, supervision to Jim, equivalent to (10,11,14)), (10,12,15), (10,14,10) (equivalent to (10,10,14)), (10,12,10) and (10,13,10). Yet this assignment is not equitable since Jules yields 11 at steel while he would yield 12 at sales, and it is not adequate since sales yield 13 in Jim's hands while they would yield 14 if performed by Jane. Moreover, we can check that none of the six assignments is equitable or adequate (if one had any of these two properties, then any fundamentally dominant assignment would also have this property, as we shall see).

A final example will introduce markets. Assume that the two jobs steelworking and sales are offered by two different firms, a steelmill and a shop, who compete for hiring Jules or Jim. Assume also that the surplus produced by a worker at a job is equally divided between the worker and the firm (the proportions could be different, but they are fixed by custom or by fairness considerations). Assume finally that Jules produces 18 at steel and 16 at sales, while Jim generates 16 at steel and 12 at sales. The arrangement of Jules at sales and Jim at steel cannot be the stable outcome of a free competitive market. Indeed, if the steelmill hires Jules rather than Jim it gains 9(=18/2) instead of 8, while Jules prefers working at the steelmill where his wage is 9 rather than at the shop where he earns only 8. On the contrary, the opposite arrangement of Jules at steel and Jim at sales is a stable competitive market outcome. Indeed, on the one hand, Jules would lose by shifting to the shop since his wage would

drop from 9 to 8, and on the other hand, the steelmill would lose by replacing Jules with Jim since its profit would drop from 9 to 8. This is the manifestation of the general property shown below that, in such a framework with any number of workers and jobs, there is one and only one stable market outcome. Furthermore, this stable market outcome may not maximize total income and thus total workers'income or total firms'income, since in this example total income is 18+12=30 for the stable market outcome while for the reverse assignment it is 16+16=32. These properties are to be compared with the classical results of the matching markets problem: on the one hand, with independent individual preferences on both sides of the market (the "marriage" problems of Gale and Shapley,1962) there generally are several stable outcomes, two of which are each equitable among stable outcomes for the agents on one side of the market (it thus maximizes these agents'total income on stable outcomes); on the other hand, with endogenous wage-profit sharing there generally is only one stable assignment which maximizes total income. If, in the example, Jim's production at sales is raised from 12 to 18, then the stability properties will not change, but the stable outcome will be equitable and adequate and will maximize total income.

3 - Relations, meanings, definition.

The properties observed in these examples will be proven for any finite number of individuals and lots, any orderings and any possible restrictions on the set of assignments. In particular, if in assigning given lots to given individuals both equitable assignments and adequate assignments can exist, then each assignment which has one of these properties also has the other one. But there can also exist equitable assignments and no adequate ones, or adequate assignments and no equitable ones, or neither an equitable nor an adequate assignment, as the above examples have shown. Thus, if both equity and adequacy can exist, these properties will compound their meanings in the same assignments. Hence, when only one of these properties can exist, it can be considered as an extension of the other property to problems where the latter is ineffective. Furthermore, since equity or adequacy imply fundamental dominance while fundamental dominance can exist with neither equity nor adequacy, fundamental dominance can be considered as

an extension of equity or of adequacy for problems where these properties or criteria are ineffective.

These logical relations are valuable since in most applications these properties have quite different semantic requirements (i.e., what is necessary for each of them to be meaningful), quite different ethical meanings when they are given an ethical interpretation, more generally different normative meanings, and they also have different scopes of logical applicability and of existence, and from all these viewpoints different strong points and different limitations. The discussion of these aspects is essential, although we wish to keep it here to the strict minimum. Consider for instance the ethical reasons for considering these properties. "Minimal reflective equilibrium" implies at least making explicit the following remarks.

Equity, adequation and fundamental dominance are ordinal properties in the sense that they require only ordinal comparisons of pairs of an individual and a lot.

Consider equity in its classical meaning, that is, defined with individuals' preferences. i,j,... are indices of individuals. Individual i has the lot x_i and the preference ordering $\underset{i}{\succsim}$ (preferred or indifferent to). Equity is $x_i \underset{i}{\succsim} x_j$ for all i,j. We shall add below possible restrictions of the comparisons of the assignments of the x_i's. Equity is interesting because it has a set of more basic meaningful properties. Each of these properties comes from equity being implied by some fact or implying it. These basic properties belong to three categories. The most important category constitutes its cautious, sensible and diffuse egalitarianism. The second one is related to unanimity and exchange among re-assignments. The third one is its minimal requirements with respect to preferences. We consider them in reverse order.

A- Preference requirements.

1) Equity does not require any inter-individual comparability of individual preferences.
2) Equity is an ordinal property, i.e., it requires only the existence

of individual preference orderings.

B - Unanimity and exchange.

1) Equity implies unanimity in the sense of unanimous preference (or indifference) over all considered reassignments of lots. It is thus in particular Pareto-efficient in the set of these assignments.

2) Equity implies stability (or equilibrium) with respect to unanimously accepted or desired reassignments (strictly desired by at least one individual),; that is, no such reassignment is possible from an equitable situation. In particular no two-by-two voluntary exchange of lots is possible from an equitable situation.

C - Egalitarianism. Equity can be called utilitarist, preference-respecting, ordinal, non-interpersonally-comparable egalitarianism. Its meaningful, cautious and multi-faceted egalitarianism is its main claim to our consideration. Its cautious aspect comes from properties a: reliance only on ordinal, non-intercomparable individual preferences. Its egalitarianism comes from several of its properties. It should firstly be emphasized that egalitarianism in general (1) can be defined on different variables with consequences which can be different or even opposed (allocations, welfares, rights, freedoms, weights of utility, etc.), (2) can be held for bad or good reasons, and (3) can be considered as an end in itself or as a means to something else. Jealousy and envy are generally considered bad reasons for desiring equality. An aesthetic taste for symmetry is not an acceptable reason either. On the other hand, to satisfy certain minimal needs or freedoms of the worse-off and of the least free people may justify some not too unequal distributions and equalizing constraints or transfers. And the only acceptable justification for equality as an end is the "principle of unsufficient inegalitarian reason": equality is chosen when there is no good reason for inequality (this is a logical justification, but deciding what reasons are good or not is an ethical choice(10)). Finally, equality may be sought for the sake of social peace and harmony in the presence of propensities to jealousy, envy or sentiments of arbitrariness. Equity has the following egalitarian aspects.

1) Equity is an extension of "equality of opportunity"[11]. If individuals have the same possibility set and freedom to choose, their resulting individual choices will be equitable (since each individual could choose a lot identical to the one of any other and he prefers the one he chooses). But this complete equality of opportunity may be impossible (for instance, individuals have different talents). Equity, then, is this extension.

2) With equity, each individual is not worse off than he would be with any other individual's lot.

3) With equity, no individual receives a lot that some other individual would prefer to his own. That is not a morally good egalitarian reason.

4) Equity is symmetrical bilateral reciprocity for each pair of individuals and each pair of lots, in that each individual does not prefer the other's lot.

5) Equity is the identical preference or indifference of all individuals over all reassignments of lots between them.

6) If all lots are equal in the sense of identical, the situation is equitable. Yet, this equality may be impossible; or it may fail to have some otherwise desired property such as Pareto-efficiency, or the allocation of certain situations or commodities to certain individuals (for reasons of need or respect of rights or of freedom of action or exchange, etc). Then, if equity is possible, or if it is furthermore consistent with these properties, the situation can have the equity property of this allocative equality, plus eventually the other required properties. Equity thus can be an extension of equality when equality is impossible or bad for some reason.

7) If all individual preference orderings were identical, equity would mean that all individual lots are in the same indifference locus[12]. If furthermore these orderings could be represented by the same utility function (with some specifications of the ordinal utility), equity would mean that all individuals have the same utility

level --the same welfare level if that were the meaning of this utility.Thus, equity can be considered as an extension of equal utility or equal welfare when these expressions are meaningless because individual preferences are not comparable.

8) If the problem is to divide a given quantity of a desired commodity, equity yields equal division. Thus equity is an extension of equal division when the nature of the lots is more complex so as to permit differences in individual preference orderings.

9) Equity describes a certain non-envy or non-jealousy[13]. However, these sentiments have the following ethical features.

a) It is generally considered that the envious or jealous individual is responsible for his sentiment of envy or jealousy. Therefore, for example, such a sentiment per se is not considered a good reason for this individual to receive more at the detriment of somebody else.

b) Envy is not considered a good sentiment, it is considered that the the envious person is to be blamed for it. (J.S. Mill calls envy "that most odious and anti-social of all passions" in On Liberty). Thus to accept that envy influences the state of society may even be a particularly immoral social choice.

c) Yet, precisely because envy is considered ugly, an envy-less society is better, all other things being equal (the sentiments which exist in a society are certainly relevant and important aspects for judging the society).

d) Envy and jealousy are common causes of latent and open strife and hostility in the society. Thus non-envy and non-jealousy may be sought for the sake of peace and social harmony.

The last two reasons are second best ones: they hold given that these sentiments exist, given that moral education, preaching and appeal to reason fail to suppress them.

Our second property, adequacy, tackles the allocation problem

more directly since it rests on a capacity to say whether it is better that some lot is attributed to some individual or to some other (a capacity that is in particular implied by any allocative judgment which can compare all distributions). And fundamental dominance results, we have seen, from unanimity (or its equivalent for the relevant individual-dependent orderings) and independent impartiality. Section 10 below shows a deep meaning of fundamental dominance: it is an extension of the two-individual meaningful comparisons of variations in ordinal utility to the cases with any number of individuals. However, both adequacy and fundamental dominance (for independent impartiality) require inter-individual comparisons. That may or may not raise a problem, depending on the case. This is the topic of the next section. But we first need some notation.

Again integers i,j,..., are indices of individuals and x_i represents the lot of individual i. But we now add y_i which represents a sufficient set of characteristics of individual i. (In other words, y_i is what i is and x_i is what i has). The expression (x_j, y_k) means individual k with the lot x_j of individual j. We also have a preference ordering with preference, indifference, or preference or indifference, represented respectively by $>$, $\sim$, $\gtrsim$. The situation is adequate if

$$x_i, y_i \gtrsim x_i, y_j \quad \text{for all } i,j.$$

It is equitable if

$$x_i, y_i \gtrsim x_j, y_i \quad \text{for all } i,j$$

(this is the classical definition of equity if for each i this expression represents $x_i \gtrsim_i x_j$ where $\gtrsim_i$ is individual i's preference ordering). Since, for given x_i's and y_i's for all i 's, the set with elements (x_j, y_k) is denumerable, for defining equity or adequacy the ordering $\gtrsim$ is representable by a utility function u. Then, writing $u(x_j, y_k) = u_j^k$ and considering the matrix of the u_j^k with row j and column k, adequacy means that the principal diagonal dominates in rows while equity means that it dominates in columns. Finally, $\sigma(i)$ and $\tau(i)$ denoting permutations of the indices and $\tau\sigma(i)$ denoting the product of $\sigma(i)$ by $\tau(i)$, the situation is fundamentally dominant if for each σ there exists a τ such that, for all i 's,

$$x_i, y_i \gtrsim x_{\tau\sigma(i)}, y_{\tau(i)} \quad \text{or} \quad u_i^i \geq u_{\tau\sigma(i)}^{\tau(i)}$$

(or alternatively $x_i, y_i \gtrsim x_{\tau(i)}, y_{\tau\sigma(i)}$ or $u_i^i \geq u_{\tau(i)}^{\tau\sigma(i)}$).

We remark that if and only if this τ can be the identity 1 for each σ,

the condition becomes equity in the first formulation (and adequacy in the alternative one); and if and only if it can be $\tau=\sigma^{-1}$ for each σ, the condition becomes adequacy in the first formulation (and equity in the alternative one).

4 - Examples and cases of applicability.

We now propose a few examples to suggest possible domains of relevance of these concepts. The question of relevance can be posed at two levels: meaningfulness of the comparisons of situations (i.e., meaningfulness of the ordering and, in particular, of its comparison across individuals), and meaningfulness of the properties (adequacy, equity, fundamental dominance and others introduced later, such as fundamental efficiency, free-exchange stability, etc.).

A - Attributions. Comparing the attribution of a lot to various individuals is sometimes banal. For instance, most people would say that a book in Japanese is more useful if attributed to someone who can read Japanese rather than to someone who cannot. Then, if we consider that to allocate the book is to assign the two lots "the book" and "nothing", giving the book to the Japanese reader is adequate. It is also equitable if the individual who cannot read the book does not care for it (assuming that the Japanese reader profits from or enjoys reading the book). However, if the non-reader would prefer even slightly to have the book (for instance for decoration or for the paper), this allocation is no longer equitable in the classical sense although it might remain adequate.

B - Quantitative outcomes. Another example which applies to a number of cases occurs when the relevant effect of attributing lot x_j to individual k is a monetary benefit, net gain or cost saved (or loss) v_j^k, independent from the attribution of the other lots to the other individuals. If these benefits are received by the same agent, then we have an extension of the first example of section 2 to any number of individuals (and any cause of the gains). If the benefit created by the attribution of x_j to individual k (i.e., by the pairing x_j, y_k) accrues to individual k, then equity has its classical meaning. These "individuals" can also for instance be profit maximizing firms. Whoever

receives the benefits, the idea that, other things being equal, it is better to attribute x_i to individual i than to individual j if $v_i^i > v_i^j$ is a widespread ethical position, expressed by the argument that individual i makes a better use of x_i than individual j does. If these benefits accrue to different individuals amongst whom additional lump-sum transfers are possible, this view can be related to Pareto-efficiency. Yet, it is often held even without such transfers. In economics, this is related to several classical discussions (Hicks'welfare criterion, Posner's wealth maximization criterion, etc.). Then adequacy which takes the v_j^k as a specification of the u_j^k is a meaningful concept. Also, in a number of cases, the relation $\succsim$ can be $\geq$ concerning quantities of an output, or economized quantities of an input, if that is the relevant variable. When the v_j^k are homogeneous quantities like incomes, quantities of an output, etc., the total sum $\sum_i v_{\sigma(i)}^i$ and the conditions of its maximum (minimum for inputs or costs saved) are often relevant aspects.

C - **Bidding**. When v_j^k is the money value of lot j for individual k, it can be the (maximum potential) bid that individual k is ready to offer for lot j. Then, in this sense, one can say that the assignment is adequate when each lot is attributed to its highest bidder, and that it is equitable when each individual receives the lot for which he offers his highest bid (with possibilities of ties). The result shown below says that it may be that only one, or the other, or both, or none of the two properties are possible, but that if both are possible any assignment which has one property also has the other. In this case an auction market achieves both properties[14].

D - **Matchings**. The equity-adequacy properties and relations also apply to the important "double equity" properties in bilateral matchings with fundamentally consistent individual preferences, that is to say to the following case. A bilateral matching is an assignment problem between two groups of n agents each. Each of the 2 n agents has a preference ordering over his possible partners. Examples are monogamous marriage, assignment of workers to firms, of plants to locations with land owners, of houses with owners to tenants or to buyers, etc. Cases when one agent can have several partners (several workers to firms, ownership of several houses on land tracts, etc.) can be reduced to this one when this agent's utility (his profit for instance) is

additively decomposable with respect to these items. The outcome of each pairing is assumed to directly concern only this pair of agents. The "fundamental consistency" of individual preferences means that these n^2 outcomes can be classified in an order of desirableness with which each agent agrees for his ordering of the n possible outcomes of his own matchings with the others (in fact, it may be that only a subset of the pairings are considered). If i and i' are agents on each side, (ii') denoting their pairing and $\succsim_i$ being agent i 's preference ordering, this fundamental consistency can also be defined by the impossibility, for any set of the considered pairs, of relations such as $ii' \succsim_i ij' \succsim_j jj' \succsim_{j'} ji' \succsim_{i'} ii'$ with strict preference in at least one of the four relations. Fundamental consistency often results from the fact that the relevant outcome of each pairing can be sufficiently described by a quantity that both agents prefer to be higher or lower: an income, a quantity of a product, a cost or a quantity of an input saved. This is in particular the case in the two situations of monotone sharing or of joint consumption of this quantity by these two agents. Monotone sharing means that this quantity (product or income received or cost to be paid by the pair) is shared by the two agents in such a way that an agent receives (or pays) more when he is in a pair which receives (or pays) more. For example, an agent could receive (or pay) a proportion of the income (or cost) which is the same for all agents on one side, or even for all agents --then it is one half. Such "splits" are frequent, with proportions determined bycustom, past bargaining or considerations of fairness. One sees that it is quite usual to have monotone sharing of the worker's productivity between profit and wage, of economic land rent between the land-owner and the firm, of the tenant's willingness to pay between himself and the house owner, etc. The joint consumption case means that this quantity is a public good for the two paired agents. In section 11 we shall argue that marriage tends to be of the joint consumption or of the monotone sharing type.

In these cases, the equity-adequacy properties refer to equity on each side of the matching. Furthermore, in such problems the results of free exchange choices or market situations are often an important question which has notable relations with the equity structures. Also, when the relevant outcomes are quantities of the same good (incomes, products, costs or inputs), one is in addition generally interested in

conditions for maximal total income or product or minimal total cost. Moreover, not all assignments and in particular pairings may be relevant (for instance possible or stable). There can be equity on one side (mono-equity), on both sides (bi-equity), or on none. A result is that if for each side equity is possible, then all equity is bi-equity. Furthermore, any equity maximizes total income or product (or minimizes total cost) if that is the relevant variable. Also, as an example in section 2 has suggested, there generally is only one stable outcome (market equilibrium), which may not maximize total product. These results are proven in section 11 as an application of the general properties.

E - An "ethical observer". In other applications of the structures and properties considered here, the relation $\succsim$ represents ethical evaluations of an "ethical observer", perhaps describing his views about welfare comparisons. If the ordering $x_i, y_i \succsim x_j, y_j$, for given i, coincides with $x_i \succsim_i x_j$, this observer "respects" individual i 's preferences on the relevant domain, and the relation $x_i, y_i \succsim x_j, y_j$ are his inter-individual comparisons.

F - Fundamental preferences. Furthermore, if, for a given set of individuals i, a domain $X \ni x$ (which includes the lots x_i), and individual i 's preferences $\succsim_i$ comparing the x, there exist sets of characteristics y_i and an ordering $\succsim$ independent of i such that the (x, y_i) for given i are ordered by $\succsim$ as the x are ordered by $\succsim_i$, for each i, we call $\succsim$ a "fundamental preference ordering" for this problem (and work with it is "fundamental analysis"). The existence of a fundamental ordering is unproblematic in many situations (for example in the "quantitative outcome" case, where the relevant variable of each attribution of a lot to an individual is a quantity of the same variable --money gain, loss or cost, or a given output or input-- which all individuals prefer to be either larger or smaller). For fundamental preferences, or for an ethical observer respecting individual preferences, the y_i are sets of characteristics which sufficiently correlate with individuals i 's preferences. In particular, y_i can be the ordering $\succsim_i$ on its relevant domain. The ordering $\succsim$ is then defined

as ordering pairs $(x_i, \underset{\sim}{\geq}_i)$, giving a meaning to comparisons such as $(x_i, \underset{\sim}{\geq}_i) \underset{\sim}{\geq} (x'_i, \underset{\sim}{\geq}_i)'$, with

$$(x_i, \underset{\sim}{\geq}_i) \underset{\sim}{\geq} (x'_i, \underset{\sim}{\geq}_i) \Leftrightarrow x_i \underset{\sim}{\geq}_i x'_i$$

(and corresponding formulations with a fundamental or ethical utility functional $u[x_i, u_i(.)]$). The questions raised by the existence of a fundamental or ethical ordering $\underset{\sim}{\geq}$ depend on the extent and homogeneity of the set of individuals i, and on the lots x_i and domain X. An ethical observer's ordering can always be assumed. But it is even possible to assume that a fundamental preference ordering exists for any set of individuals (in the strict sense, "physical" ones) and any X. This is a presupposition about human rationality. To adopt it is to take a position in philosophical anthropology (i.e., about "human nature"). As several other, more usual, basic presuppositions about human rationality (transitivity of choice, existence of preferences and their relation to action, free will, etc.), this one cannot be "proven" true or false for several reasons, and its justification largely relies on its eventual fruitfulness. Indeed, this assumption is often fruitful or even necessary both for explaining differences in "tastes" and in resulting choices and actions, and for normative inter-individual comparisons of individual orderings or utilities. This philosophical discussion is beyond our scope here. In many questions the relevant differences between the y_i's are clearly definable. Unavoidably, all works in theoretical, empirical or applied economics which consider causes of variations in tastes across individuals use some kind of fundamental preferences. This probably covers hundreds of studies, and they do it without prior discussion[15]. Also, an ordinal fundamental ordering is necessarily implied by the rather usual common-speech assertions or assumptions that someone is or can be happier, more satisfied, better off, etc. than someone else.

G - <u>The general case of a deep ordering structure</u>.

Problems with either fundamental preferences, quantitative outputs (income, wealth, product, cost saved, etc.), matchings with fundamentally consistent preferences (e.g., because of joint consumption or monotone sharing), or an "ethical observer" respecting individual preferences, etc., all share the following common structure:

which is sufficient for some of the crucial properties shown below. With i,j=1,...n, there are 2n orderings of pairs (ij), one for each given i or j, written $\underset{i}{\succ}$ and $\underset{\tilde{i}}{\succ}$ and similarly for index j. We say that these 2n orderings are "fundamentally consistent" or that they manifest a deep or fundamental ordering structure, when each is a projection of the same "fundamental ordering" of the pairs (ij), at given i or j. This can be expressed in two equivalent ways. Either there exists an ordering of the pairs (ij), the "fundamental ordering", written as $\underset{\sim}{\succ}$ and $\succ$, such that $ij \underset{\tilde{i}}{\succ} ik \Leftrightarrow ij \underset{\sim}{\succ} ik$ and $ij \underset{\tilde{j}}{\succ} \ell j \Leftrightarrow ij \underset{\sim}{\succ} \ell j$ for all i,j,k,ℓ. Or, for all i,j,k,ℓ, we do not have the set of relations $ij \underset{\tilde{i}}{\succ} ik$, $ik \underset{\tilde{k}}{\succ} \ell k$, $\ell k \underset{\tilde{\ell}}{\succ} \ell j$, $\ell j \underset{\tilde{j}}{\succ} ij$ with the strict relation $\underset{i}{\succ}$ or $\underset{j}{\succ}$ or $\underset{k}{\succ}$ or $\underset{\ell}{\succ}$ in at least one case. Then the properties studied here have meaning and their relations hold. These orderings can also be defined on only a subset of the n^2 pairs ij.

5 - Summarized examples of situations.

In particular, when fundamental preferences or an analogous structure (quantitative output, ethical observer, etc.) exists for a given question and given situations, this has two consequences. First, adequacy is a meaningful property. Second, if the corresponding characteristics y_i contain all the relevant reasons for discriminating between the various individuals in each of the situations which the allocation problem compares (rather than in all these situations taken together), then a permutation of the i in a situation, transforming each (x_i, y_i) into $(x_{\sigma(i)}, y_{\sigma(i)})$ while this operation is not performed in the other situations, does not change the comparison problem; then there is "independent irrelevance" of permutations, and fundamental dominance of a situation over another one is equivalent to the corresponding unanimous preference or equivalence.

Before considering the general case, let us summarize some examples of structural possibilities. Tables 2 and 3 consider cases with two individuals (and two lots). Table 2 recalls possible properties of the allocation of x_1 to individual 1 and of x_2 to individual 2.

	u_1^1	u_2^1	u_1^2	u_2^2
equitable and not adequate	4	3	1	2
adequate and not equitable	4	1	3	2
both equitable and adequate	2	1	1	2
neither equitable nor adequate	2	3	3	any
neither equitable nor adequate	2	3	any	2

Table 2

Table 3 considers together the two possible assignments (x_1 to 1, x_2 to 2), and (x_2 to 1, x_1 to 2) and it shows some examples of possible and impossible situations.

$u_1^1 > u_2^1$
$\vee \quad \vee$ There is neither any equitable nor any adequate assignment.
$u_1^2 > u_2^2$

$u_1^1 > u_2^1$
$\vee \quad \vee$ One assignment is equitable, none is adequate.
$u_1^2 < u_2^2$

$u_1^1 > u_2^1$
$\vee \quad \wedge$ One assignment is adequate, none is equitable.
$u_1^2 > u_2^2$

$u_1^1 > u_2^1$
$\vee \quad \wedge$ The same assignment is both equitable and adequate.
$u_1^2 < u_2^2$

$u_1^1 > u_2^1$
$\wedge \quad \vee$ One assignment is equitable and inadequate, the other one is
$u_1^2 < u_2^2$
adequate and inequitable.

Table 3

The inequalities show that the last exhibited situation in table 3 is impossible.

Consider now the opposite extreme case of an infinite number of

individuals. Choose u_j^i 's such that, for all i 's, $u_i^i = 2i-1$, $u_{i+1}^i = 2i$, $u_j^i = 0$ for $j \neq i, i+1$. Then, the brackets {} denoting for all i 's, the assignment $\{x_i, y_i\}$ is adequate but inequitable, and the assignment $\{x_{i+1}, y_i\}$ is equitable but inadequate. Indeed, $u_i^i > u_j^i$ for all $j \neq i$ and all i but $u_i^i < u_{i+1}^i$, and $u_{i+1}^i > u_j^i$ for all $j \neq i+1$ and all i but $u_{i+1}^i < u_{i+1}^{i+1}$ (table 4).

1	0	0	0	.	.	.
2	3	0	0	.	.	.
0	4	5	0	.	.	.
0	0	6	7	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.

Table 4

However, we shall see that this kind of situation is impossible if n is finite (in accordance with the last example exhibited in the n=2 case) --it can happen with n infinite only because in $\{x_{i+1}, y_i\}$ the individual who receives x_1 cannot be designated.

II - BASIC RELATIONS.

6 _ Definitions and notation.

i,j,k,ℓ are indices ranging over the n first integers: 1,...n. $\sigma(i)$ is one of the n! permutations of the n first integers. $\sigma=1$ is the identity permutation. σ',σ'', etc. are other such n-permutations.
x_i and y_i are respectively lots and characteristics of individuals.
z_i is a pair (x_j, y_k) of a lot and of an individual defined by his characteristics. $z=\{z_i\}=(z_1,\ldots z_n)$ is a n-tuple of elements z_i for all i=1,...n. We denote

$$\sigma z = \{z_{\sigma(i)}\} = z_{\sigma(1)},\ldots z_{\sigma(n)},$$

and

$$z_i^\sigma = (x_{\sigma(i)}, y_i)$$

or

$$z^\sigma = \{z_i^\sigma\} = (x_{\sigma(1)}, y_1),\ldots (x_{\sigma(n)}, y_n).$$

z_i^σ means that individual i, with characteristics y_i, receives the lot

$x_{\sigma(i)}$, and thus z^σ represents an assignment between the n individuals and the n lots.

We remark that

$$\sigma z^{\sigma^{-1}} = (x_1, y_{\sigma(1)}), \ldots (x_n, y_{\sigma(n)}).$$

We call ρ a set of n-permutations, $|\rho| \leq n!$, and R the set of corresponding z^σ:

$$\sigma \in \rho \Leftrightarrow z^\sigma \in R.$$

We shall consider only $\sigma \in \rho$ and $z^\sigma \in R$, which will lead to concepts of R-equity, R-adequacy, R-fundamental dominance. A particular case is when ρ is the (unrestricted) set of the n! n-permutations. R stands for "restricted". An important application is when R is the set of possible assignments (we then speak of realistic equity, adequacy and fundamental dominance). Indeed, some assignments may be impossible for many possible reasons (depending on the actual problem[16]), and comparisons involving impossible ones may be irrelevant. In another application, developed in section 11 below, R is the set of stable matchings. A priori a smaller R (or ρ) is more favorable to the existence of assignments having the considered properties, as the definitions will make clear.

There is a "fundamental" ordering, with usual notation $\succ, \succsim, \sim$, which compares pairs (x_i, y_j) (it suffices that it can compare them for the same y_j on the one hand and for the same x_i on the other, for all j and i, since comparing (x_i, y_j) and (x_k, y_ℓ) can be deduced from comparing (x_i, y_j) with (x_k, y_j) and (x_k, y_j) with (x_k, y_ℓ)). That is, the fundamental ordering compares elements of type z_i.

Given $z=\{z_i\}$ and $z'=\{z'_i\}$, we write

$$z \sim z' \text{ iff } z_i \sim z'_i \ , \ \forall i \ ,$$

$$z \succsim z' \text{ iff } z_i \succsim z'_i \ , \ \forall i \ ,$$

$z \succ z'$ iff $z \succsim z'$ and not $z \sim z'$ (i.e., $\forall i: z_i \succsim z'_i$, and $\exists i: z_i \succ z'_i$).

We say that z is fundamentally equivalent to z' and write

$$z \text{fez}' \text{ iff } \exists \sigma: z \sim \sigma z' .$$

We say that z fundamentally dominates z' and write

$$z f dz' \text{ iff } \exists\sigma : z \gtrsim \sigma z' \quad (17).$$

Consider the assignment $z^1 = \{(x_1, y_1)\} = (x_1, y_1), \ldots (x_n, y_n)$.

We say that z^1 is R-fundamentally dominant and write $z^1 \in F$ or $1 \in f$ iff $z^1 \in R$ (or $1 \in \rho$) and $z^1 f dz^\sigma$ for all $\sigma \in \rho$.

We say that z^1 is R-equitable and write $z^1 \in E$ or $1 \in e$ iff $z^1 \in R$ (or $1 \in \rho$) and $z^1 \gtrsim z^\sigma$ for all $\sigma \in \rho$.

We say that z^1 is R-adequate and write $z^1 \in A$ or $1 \in a$ iff $z_1 \in R$ (or $1 \in \rho$) and $z^1 \gtrsim \sigma^{-1} z^\sigma$ for all $\sigma \in \rho$.

Obviously, $F \subseteq R$ and $f \subseteq \rho$, $E \subseteq R$ and $e \subseteq \rho$, $A \subseteq R$ and $a \subseteq \rho$. We also have $E \subseteq F$ and $e \subseteq f$, and $A \subseteq F$ and $a \subseteq f$ from the definitions (for each element of e, or of a, the fundamental dominance over each $\sigma \in \rho$ is respectively with permutation 1, or σ^{-1}).

We can now state the properties.

7 - Properties.

Theorem.

1 - If there exists one *R*-equitable and one *R*-adequate assignments, each assignment which has one of these properties also has the other.

2 - If there exists one *R*-equitable assignment, each *R*-fundamentally dominant assignment is R-equitable.

3 - If there exists one *R*-adequate assignment, each *R*-fundamentally dominant assignment is *R*-adequate.

That is,

$E \neq \emptyset$ and $A \neq \emptyset \Rightarrow E = A$

$E \neq \emptyset \Rightarrow F = E$

$A \neq \emptyset \Rightarrow F = A$.

Therefore, there are only five a priori possible situations,

$F = \emptyset$,

$F \neq \emptyset$, $E = \emptyset$, $A = \emptyset$,

$F = E \neq \emptyset$, $A = \emptyset$,

$F = A \neq \emptyset$, $E = \emptyset$,

F=E=A.

8 - Demonstration.

These properties can be proven in several ways. The following way is certainly the simplest. In addition, it has the intrinsic interest of considering a "social welfare function" of the form it necessarily has in this problem.

For given n x_i and n y_i, the set of the (x_j, y_k), which the fundamental ordering orders, has at most n^2 distinct elements, it is thus denumerable, and this ordering is therefore representable by an ordinal utility function $u(x_j, y_k)$ or $u(z_i)$. We consider any specification of this function, and any symmetrical, increasing, $\mathbb{R}^n \to \mathbb{R}$ function of the $u(z_i)$ for i=1,...n, $W[\{u(z_i)\}]$. We then denote

$w^\sigma = W[\{u(x_{\sigma(i)}, y_i)\}]$ (18),

$\mu = \max_{\sigma \in \rho} w^\sigma$,

m is the set of σ such that $w^\sigma = \mu$ $(m \subseteq \rho)$,

M is the set of z^σ such that $\sigma \in m$ $(M \subseteq R)$.

We then have the following

Lemma.

S standing for F or E or A, $S \neq \emptyset \Rightarrow S=M$ (or s standing for f, e or a, $s \neq \emptyset \Rightarrow s=m$).

That is, the assignments which maximize W on R are the R-fundamentally dominant ones, or the R-equitable ones, or the R-adequate ones, if, respectively, there exists at least one assignment in R having this specific property.

The theorem results straightforwardly from the lemma.

To prove the lemma is also easy but it should best be done

carefully. The lemma is proven if we prove that $\{1\epsilon s \text{ and } \sigma\epsilon s\} \Rightarrow w^1 = w^\sigma$, and $\{1\epsilon s \text{ and } \sigma\epsilon\rho\text{-}s\} \Rightarrow w^1 > w^\sigma$ for *s* being respectively *f*, *e* or *a*.

Fundamental dominance. $1\epsilon f$ and $\sigma\epsilon\rho \Rightarrow z^1 \, df \, z^\sigma$ (from the definition of f) $\Rightarrow w^1 \geq w^\sigma$ (since W is symmetrically increasing). Thus $\{1\epsilon f \text{ and } \sigma\epsilon f\} \Rightarrow \{w^1 \geq w^\sigma \text{ and } w^\sigma \geq w^1\} \Rightarrow w^1 = w^\sigma$. Furthermore, $\{1\epsilon f \text{ and } \sigma\epsilon\rho\text{-}f\} \Rightarrow \exists\sigma'$ such that $z^1 \underset{\sim}{\geq} \sigma' z^\sigma$. Indeed, $\{1\epsilon f \text{ and } \sigma\epsilon\rho\text{-}f \subseteq \rho\} \Rightarrow \exists\sigma'$ such that $z^1 \underset{\cong}{\geq} \sigma' z^\sigma$ (from the definition of f). And $\{z^1 \sim \sigma' z^\sigma \text{ and } 1\epsilon f\} \Rightarrow \sigma\epsilon f$ since, for all $\sigma'' \epsilon\rho$, $\{z^1 \, df \, z^{\sigma''} \text{ and } z^1 \sim \sigma' z^\sigma\} \Rightarrow z^\sigma df z^{\sigma''}$ (since $\{z^1 \underset{\cong}{\geq} \sigma''' z^{\sigma''} \text{ and } z^1 \sim \sigma' z^\sigma\} \Rightarrow z^\sigma \underset{\cong}{\geq} \sigma'^{\,V} z^{\sigma''}$ with $\sigma'^{\,V} = \sigma'^{-1}\sigma'''$). Finally, $z^1 \underset{\sim}{\geq} \sigma' z^\sigma \Rightarrow w^1 > w^\sigma$ since W is symmetrical increasing. Thus $\{1\epsilon f \text{ and } \sigma\epsilon\rho\text{-}f\} \Rightarrow w^1 > w^\sigma$.

Equity. $\{1\epsilon e \text{ and } \sigma\epsilon\rho\} \Rightarrow z^1 \underset{\cong}{\geq} z^\sigma$ from the definition of e. Thus $\{1\epsilon e \text{ and } \sigma\epsilon e\} \Rightarrow z^1 \sim z^\sigma \Rightarrow w^1 = w^\sigma$. Furthermore, $\{1\epsilon e \text{ and } \sigma\epsilon\rho\text{-}e\} \Rightarrow z^1 \underset{\sim}{\geq} z^\sigma$. Indeed, $\{1\epsilon e \text{ and } \sigma\epsilon\rho\text{-}e \subseteq \rho\} \Rightarrow z^1 \underset{\cong}{\geq} z^\sigma$. And $\{z^1 \sim z^\sigma \text{ and } 1\epsilon e\} \Rightarrow \sigma\epsilon e$, since

$$1\epsilon e \overset{\text{def}}{\Longleftrightarrow} \{z^1 \underset{\cong}{\geq} z^{\sigma'}, \forall\sigma' \epsilon\rho\} \Leftrightarrow \{z^\sigma \underset{\cong}{\geq} z^{\sigma'}, \forall\sigma' \epsilon\rho\} \overset{\text{def}}{\Longleftrightarrow} \sigma\epsilon e.$$

Finally, $z^1 \underset{\sim}{\geq} z^\sigma \Rightarrow w^1 > w^\sigma$ since W is increasing. Thus, $\{1\epsilon e \text{ and } \sigma\epsilon\rho\text{-}e\} \Rightarrow w^1 > w^\sigma$.

Adequacy. $\{1\epsilon a \text{ and } \sigma\epsilon\rho\} \Rightarrow z^1 \underset{\cong}{\geq} \sigma^{-1} z^\sigma$ (from the definition of a) $\Rightarrow w^1 \geq w^\sigma$ (since W is symmetrical increasing). Thus $\{1\epsilon a \text{ and } \sigma\epsilon a\} \Rightarrow w^1 = w^\sigma$. Furthermore, $\{1\epsilon a \text{ and } \sigma\epsilon\rho\text{-}a\} \Rightarrow z^1 \underset{\sim}{\geq} \sigma^{-1} z^\sigma$. Indeed, $\{1\epsilon a \text{ and } \sigma\epsilon\rho\text{-}a \subseteq \rho\} \Rightarrow z^1 \underset{\cong}{\geq} \sigma^{-1} z^\sigma$. And $\{z^1 \sim \sigma^{-1} z^\sigma \text{ and } 1\epsilon a\} \Rightarrow \sigma\epsilon a$, since

$$1\epsilon a \overset{\text{def}}{\Longleftrightarrow} \{z^1 \underset{\cong}{\geq} \sigma'^{-1} z^{\sigma'}, \forall\sigma' \epsilon\rho\} \Leftrightarrow \{\sigma^{-1} z^\sigma \underset{\cong}{\geq} \sigma'^{-1} z^{\sigma'}, \forall\sigma' \epsilon\rho\} \overset{\text{def}}{\Longleftrightarrow} \sigma\epsilon a.$$

Finally, $z^1 \underset{\sim}{\geq} \sigma^{-1} z^\sigma \Rightarrow w^1 > w^\sigma$ since W is symmetrical increasing. Thus $\{1\epsilon a \text{ and } \sigma\epsilon\rho\text{-}a\} \Rightarrow w^1 > w^\sigma$.

Q.E.D.

9 - Maximal global welfare or income.

The function W has the general form of a "social welfare function", which respects individuals' preference (since it is a function of z only through the $u(z_i)$ and is increasing in each $u(z_i)$) and is "impartial" in the sense that it is symmetrical in the z_i. This "impartiality" is a necessary consequence of using a fundamental utility function, as we have remarked more generally above. One such

possible function is $\Sigma u(z_i)$, which is meaningful only when adding the $u(z_i)$ is, for instance when they are incomes v^i_j as discussed above (or quantities of an output, or economized costs or quantities of an input). The lemma thus leads to the following properties.

Properties.

1 - R-equitable, R-adequate and R-fundamentally dominant allocations maximize any social welfare function respecting individual preferences, and impartial, on the assignments in R.

2 - When the relevant effect of each pairing is to produce an income (or a quantity of an output), the corresponding R-equitable, R-adequate and R-fundamentally dominant allocations maximize global income (or output) on the assignments in R (and equivalent properties hold for minimizing costs or quantities of an input).

10 - Fundamental dominance as generalizing the comparisons of variations in fundamental ordinal utility.

This section briefly presents a few aspects, properties and consequences of fundamental dominance which further justify the interest of this concept.

With $z_i=(x_i,y_i)$, $z=\{z_i\}$ $(i=1,\ldots n)$, we define "z strictly fundamentally dominates z'" by $zsfdz' \overset{def}{\Longleftrightarrow} \{\exists\sigma$ such that $z \underset{\sim}{>} \sigma z'\}$ or z sfdz' $\Leftrightarrow$ {z fdz' and not zfez'}. The relations zfdz', zfez' and zsfdz' constitute the corresponding relations of an (incomplete) ordering. The transitivity properties result directly from the definitions, and anti-symmetry " zsfdz' $\Longrightarrow$ not z'sfdz " (and non-reflexivity "not zsfdz") can be proven in several ways. When the ordering $\underset{\sim}{>}$ on the z_i is representable by a utility function $u(\zeta)$, the simplest way is to consider as above a symmetrical increasing function W, for which $zsfdz' \Longrightarrow W[\{u(z_i)\}]>W[\{u(z'_i)\}]$. More generally, anti-symmetry can be shown from the consideration of "ordered states". Calling σz a "permuted state" of z, we call an "ordered state" of z, $\tilde{z}$, a permuted state of z such that $\tilde{z}_i \underset{\sim}{<} \tilde{z}_{i+1}$ for all $i=1,\ldots n-1$. Then the relations fd, fe, sfd, can be shown to be equivalent to $\underset{\approx}{>}, \sim, \underset{\sim}{>}$ between the

corresponding ordered states[19]. If $z \in Z$ where Z is a possibility set, we say that z is "fundamentally efficient" if $z \in Z$ and no $z' \in Z$ is such that z'sfd z.This "fundamental efficiency" criterion is a necessary consequence of Pareto-efficiency and "independent impartiality". The set of the fundamentally efficient states is a subset of the set of the Pareto-efficient ones, and a priori a much smaller subset when *n* is larger (and *Z* less "symmetrical" with respect to permutations of the z_i). This restriction is the contribution of the "independent impartiality" property to the definition of the best choice.

Finally, fundamental preferences (or their equivalent seen by an observer) enable one to make inter-individual comparisons of levels of satisfaction, happiness, utility, etc., but a priori they do not allow one to make inter-individual comparisons of variations in utilities, or of intensities of preferences, as long as it remains a purely ordinal concept. This a priori makes fundamental preferences by themselves unable to judge distributional differences between states, and it thus impairs their possible contribution to the definition of the optimum. However, fundamental preferences or their equivalent partially allow inter-individual comparisons of variations in utilities, or in intensities of preferences, and this permits the restriction of the set of possible optima in a way which turns out to be that of fundamental dominance , that is, in particular, which restricts efficiency to fundamental efficiency.

Indeed, if we call ordinally invariant a relation which remains the same when u is replaced by any increasing function of itself, calling ζ^k various specifications of the z_i, the relation $u(\zeta^1)-u(\zeta^2) = u(\zeta^3)-u(\zeta^4)$ is ordinally invariant if and only if $\zeta^1 \sim \zeta^3$ and $\zeta^2 \sim \zeta^4$, and the relation $u(\zeta^1)-u(\zeta^2) > u(\zeta^3)-u(\zeta^4)$ is ordinally invariant if and only if $\zeta^1 \underset{\sim}{>} \zeta^3$ and $\zeta^4 \underset{\sim}{>} \zeta^2$ without indifference in both relations. Therefore, and for the more general case of a fundamental ordering, given two states for two individuals 1 and 2, $z=(z_1,z_2)$ and $z'=(z_1',z_2')$, it is ordinally meaningful to say that 1 prefers z' to z more than 2 does if $z_1' \underset{\sim}{>} z_2' > z_2 \underset{\sim}{>} z_1$ with at least one of the two $\underset{\sim}{>}$ being the strict $>$. And it is ordinally meaningful to say that 1 prefers z' to z more than 2 prefers z to z' if $z_1' \underset{\sim}{>} z_2 > z_2' \underset{\sim}{>} z_1$ with

at least one of the two $\succsim$ being the strict $\succ$; we notice that this case plus the one obtained by permuting the two individuals are z'sfdz and not $z' \succsim z$. In the same way, it is ordinally meaningful to say that 1 prefers z' to z as much as 2 prefers z to z' if $z'_1 \sim z_2 \succ z'_2 \sim z_1$; we notice that this case plus the one obtained by permuting the two individuals are z' fez and not $z' \sim z$. When the individuals both prefer the same state, to choose it results from unanimous preference. When each prefers a different state, to choose the one which is more preferred to the other than the latter is preferred to it when this expression is meaningful as explained above, is to comply with fundamental dominance --of which unanimous preference is a subcase. Fundamental dominance, in general situations, is the extension of this inter-individual comparison of variations in ordinal preference levels to any number of individuals[20].

III - APPLICATIONS.

11 - Applications to bi-lateral matchings and in particular to the economic theory of marriage.

The foregoing analyses and results have important applications in the problems of bi-lateral matchings with a fundamentally consistent set of preferences. Section 3-E presented justifications and examples of this situation (assignment of employees to firms in the labor market, market for sites, houses or cars, etc.). For the sake of concreteness, we consider here the case of marriage.

a) Happy and stable marriages.

Monogamous marriage is an important assignment problem of indivisible lots. But in this case, the lots --whether the wives or the husbands-- also have preferences of their own. In our western, romantic view of love, one likes to think that the woman each man marries is the woman he prefers, that she is his first best choice, and similarly for women choosing men. But if one matching satisfies this condition for men's preferences, and another one for women's preferences, what is to be done ? What if Jules prefers Jane to Jill, Jim prefers Jill to Jane, but Jane prefers Jim to Jules, and Jill prefers Jules to Jim? As popular wisdom says, there can be more or less happy marriages. Assume

therefore that marriages can be so ordered, and that any individual prefers to make a happier marriage. Then the above theorem asserts that such a dilemma cannot arise whatever the number of individuals and couples (this number being finite). Women have their way when men do and they can as well let them choose, and conversely. Men's non-jealousy and women's non-jealousy, if each can be achieved by some matching , necessarily coincide.(At least the preference for one's mate is the expressed preference, and this result shows how these preferences can be consistent). The above results also show that if the quality of a marriage can be measured by an income of the couple (including the "psychic income" components) along G. Becker's lines (in Schultz,1974), then these "bi-equitable", jealousy-free, matchings maximize the sum of these incomes. Finally, this arrangement is obviously stable, if we say that a matching is stable if there does not exist a pair of a man and a woman belonging to different couples who both prefer to marry each other instead (stable sortings are the equilibria of the "marriage market", they constitute the core of the "marriage matching game", they result from freedom of matching).

The results of the previous sections also show that these properties equally hold if we restrict the set of the marriage arrangements which we consider to a subset of the n! sortings. In particular, they hold if we restrict our consideration to the set of stable sortings.

This coincidence of preferences of the sexes seems to oppose the result of strict opposition of the interests of the sexes obtained by the classical economic theory of marriage. Indeed, this theory, where each individual has a strict preference ordering of the individuals of the opposite sex, finds that : a stable matching exists, there exists one stable matching in which each man marries the woman he prefers among all the women which he could marry in stable matchings, there exists one stable matching with the symmetrical property for women (Gale and Shapley,1962), the mentioned stable matching which is the best one for all men is the worst stable matching for all women, and symmetrically for the women-preferred stable matching which is the worst one for all men (Knuth,1976). That is, with freedom of marriage ruling out the existence of unstable matchings, if each man enjoys the

best possible wife for him, which is possible, then each woman is afflicted with her worst possible husband, and conversely in inverting the sexes'roles.

The only way in which these classical results and ours can be reconciled is that there exists only one stable matching, since it is then at once the best one and the worst one for each individual.

What has been added to the classical theory, which leads to this uniqueness, is the "fundamental consistency" of individual orderings.It is implied by the expression a "more or less happy marriage", and it will receive more justification below by considering the "joint consumption" and "monotone sharing" aspects of marriage. It consists in considering that marriages can be ordered, with any individual's preference coinciding with this ordering for the marriages he is a part of. This "consistency" imposes some coincidence of interest between opposite sexes which results in this uniqueness.

This unique stable sorting is easily characterized. It can be constructed by pairing the man and the woman whose marriage is the best of all, then the man and the woman whose marriage is the best of all possible with the n-1 remaining men and the n-1 remaining women, and so on[21]. Indeed, let us make the indices coincide for the pairs so constituted, and let us classify these pairs in the order of their constitution, that is in decreasing[22] order of marriage quality. Write $>$ the fundamental relation ordering marriages ij of man i and woman j. By construction, we have $ii>jk$ if $j\geq i$ and $k\geq i$ without $j=k=i$. This matching is stable since in any other marriage the spouse with the lowest index is worse off than he/she was in this matching (consider another marriage ij with $i\neq j$; if $i>j$, $jj>ij$ and woman j prefers her initial marriage; if $i<j$, $ii>ij$ and man i prefers his initial marriage). Furthermore, this matching is the only stable one.Indeed, the first of the marriages of the considered matching that another matching breaks, when these marriages are considered in increasing order (i.e., decreasing quality), is considered better by the two spouses than their lot in this other matching (if $\sigma(i)$ is man i 's wife in this other matching , call j the index such that $\sigma(i)=i$ for $i<j$ and $\sigma(j)\neq j$, then $jj>j\sigma(j)$ since $\sigma(j)>j$, and $jj>\sigma^{-1}(j)j$ since $\sigma^{-1}(j)>j$).

Let us say that a matching is Pareto-efficient, or male-Pareto-efficient, or female-Pareto-efficient, when no other matching is preferred by all individuals, or by all men, or by all women, respectively. Then this stable outcome is Pareto-efficient, male-Pareto-efficient and female-Pareto-efficient, since in any other matching the man and the woman of the first couple which is broken when couples are considered in increasing order (decreasing quality of marriage) both become worse off.

If equity is possible for men, or for women, the equitable matching (which is unique because of the strict preferences hypothesis in this section) is obviously stable. Then the uniqueness of the stable matching implies that if equity is possible for men on the one hand, and for women on the other hand, the same matching is bi-equitable (this constitutes another possible proof of this property).

2 - Marriage and income.

A second trend of the classical economic theory of marriage follows Becker's pioneering and bold study mentioned above in assuming a household's overall income (including the "psychic" elements) which is shared between the spouses. Becker then showed that stable matchings maximize total social income, as in other matching problems with a similar structure.This, however, implies that a couple's income can be freely divided between the spouses.Indeed, call $v_j^i = m_j^i + w_j^i$ the income of the marriage of man i with woman j, where m_j^i goes to the husband and w_j^i goes to the wife. Consider the situation where man i marries woman i for all i 's and where they receive m_i^i and w_i^i. By definition, this situation is stable when there does not exist i,j,m_j^i,w_j^i such that $m_j^i > m_i^i$ and $w_j^i > w_j^j$. There exists such a quadruplet if there exists a pair i,j such that $v_j^i > m_i^i + w_j^j$ since, then, the possibility to share arbitrarily v_j^i between m_j^i and w_j^i implies that there exists two such numbers such that $m_j^i > m_i^i$ and $w_j^i > w_j^j$. Thus stability implies $v_j^i \leq m_i^i + w_j^j$ for all i,j (indeed, it is equivalent to this condition since an unstable pair i,j violates it). Then, if $j=\sigma(i)$ defines another matching , replacing in the above inequality and summing for all i gives

$$\Sigma v^i_{\sigma(i)} \leq \Sigma m^i_i + \Sigma w^{\sigma(i)}_{\sigma(i)} = \Sigma v^i_i .$$

Although compromise and competition do figure among the features of marriage formation, such sharing of a household's overall income, with full flexibility and induced by competition, may not capture the most important characteristics of this complex process. Joint consumption, love, fairness, duty, social norms, etc., produce other structures and results. In particular, even if we keep the notion of a household's overall income (including psychic elements), two other simple models stand a good chance of being more adequate than the former one --although in reality all the mentioned phenomena co-exist. One is the public good or joint consumption model in which $v^i_j = m^i_j = f^i$. Probably more items, or aspects, of a household's production are jointly consumed by the spouses than shared in rivalry between them (children, many items of the household's house and equipment, status, etc.). Even what seems to be one spouse's individual consumption is enjoyed by the loving mate. And it is even inherent in love that one enjoys the other's enjoyment (indeed, the expression that parents "consume" children --common in studies in the economics of the family-- leads one to say that the spouses similarly "consume" each other). The second formulation consists in saying that the household's income is shared between the spouses according to some criterion determined by sentiments of love or reciprocity or fairness, by sense of duty, or by behavior following social norms or customs (or laws), with monotone sharing in the sense that an individual's income is higher in a couple which produces more. In both models, each spouse prefers a higher v^i_j.

In these cases, man i and woman j do not prefer their voluntary marriage to what they obtain in the sorting of k with k for all n k if and only if $v^i_j \leq v^i_i$ or $v^i_j \leq v^j_j$, that is,

$$v^i_j \leq \max(v^i_i, v^j_j) .$$

The matching of k with k for all n k is stable if and only if this relation holds for all i,j. This is the solution described above for an ordinal structure --if we classify the i 's in decreasing order of the v^i_i--, which was shown to exist and to be unique. But now this stable solution does not maximize total income. There may exist $\sigma(i)$ such that $\Sigma v^i_{\sigma(i)} > \Sigma v^i_i$. Consider for example the following matrix of the v^i_j: $\begin{matrix} 4 & 3 \\ 3 & 1 \end{matrix}$. The diagonal sorting of man 1 with woman 1 and man 2 with woman 2 is

stable since $v_2^1 = v_1^2 < v_1^1$. Yet it yields a global income of 4+1=5 while the reverse sorting yields the global income of 3+3=6 (but this alternative sorting would not be stable since man 1 and woman 1 prefer marrying each other[23]). This inefficiency of free exchange and of market equilibrium may provide a rationale for imposing marriages, or for limiting free choice of mates, along with income or material transfers, which is a common feature of "traditional" societies.

However, adequate or equitable matchings defined by either $v_i^i \geq v_j^i$ for all i,j, or $v_i^i \geq v_i^j$ for all i,j, satisfy the above stability condition and are equilibria or core solutions, and they maximize global income produced by the matching, $\sum_i v_{\sigma(i)}^i$. Matchings of each of these two categories are "equitable" for one sex, and adequate for the other with the individual incomes (the v_j^i or the "monotone" shares) as criteria. The above theorem says that if it is possible to avoid men's jealousy, and if it is possible to avoid women's jealousy, then non-jealousy of one sex implies that of the other; but it may be that only one sex's jealousy can be avoided, or that jealousy is unavoidable.

All these properties remain valid if we restrict the set of marriages considered. This restriction is introduced in the definitions of the best marriage in various sets, of jealousy and non-jealousy, of equity and adequacy, and of the maximal income. This validity is easily verified in considering each reasoning (and from the general previous results applied here). Such restrictions are particularly significant for marriage theory since societies are characterized by restrictions they impose on marriages (incest prohibitions, no inter-caste, inter-class or inter-cultural or national marriage, endogamy or exogamy, age-class restrictions, etc.).

Proposition : With a fundamentally consistent set of individual preferences (due for example to joint consumption within pairs or to monotone sharing), there is one and only one free exchange stable matching. When a pair's income is defined, this equilibrium outcome may fail to maximize total income. When equity is possible for either side of the market, this outcome has this property and it maximizes total income when income is defined. When equity is possible for each side of the market, equity for any side occurs only in the stable bi-equitable

sorting.

12 - An application to market equity and to causes of wage rigidities : Tinbergen-equitable wages.

a) The problem.

Relations between justice and freedom are among the most important questions. In particular, some ideas of what is just, fair or equitable may interfere with free choice, free exchange and free market, and with the efficiency they entail. Free choices and exchanges may violate some fairness criteria, or they may on the contrary implement them. When they violate them, this is a most common reason for limiting these freedoms, usually through some form of collective action.For example, ideas about fair wages, just prices or equitable pay often result in non market-clearing wages or prices, which can in particular cause "involuntary unemployment". The importance of considerations of this type in the process of wage determination seems obvious. It is shown in hundreds of studies in the fields of labor or industrial relations (which specializes in this topic), sociological investigations and psychological experiments[24]. A number of economists have also mentioned it, and, more recently, the economic literature has shown consequences of related attitudes on decreases in the variability of prices (Kahneman, Knatsch and Thaler, 1986a and b), on the narrowing of wage differentials (Frank, 1984,1985), on unemployment (Akerlof, 1982,1988, Kolm, 1986,1988a and b) and for fiscal policy (Kolm, same references).

In particular, a most common sentiment about fair remunerations is that a wage is justifiably higher than another one if it compensates a labor which is more painful, dangerous, tiring, tiresome, boring, dirty, lacking in status or glamour, or more disagreeable in any other way, or which requires more time, effort or money for training or education. But what wage differentials would this opinion justify, given that different individuals may have different preferences on all these aspects and on income? An answer which compares the wage levels pair-wise,which is based only on individual preferences and respects them, which requires only ordinal individual preferences (orderings),

and which does not require any inter-individual comparison of preferences, necessarily has the following form: "I prefer my wage with my occupation to having your wage and your occupation", you have the symmetrical preference, and this holds for any pair of individuals in the set under consideration. This was the answer provided by Ehrenfest to a query from Jan Tinbergen in the early forties (Tinbergen,1953,Pen,1971). This criterion is "equity" as defined above applied to lots which are pairs of an occupation and of the corresponding wage. This will be called Tinbergen-equity.

We consider a set of n individual "workers", each of which has a labor occupation or job (of any type) and a wage w_i. i,j,k=1,...n are indices. A set of one w_i for each individual i, $\{w_i\}$, is called a wage profile. Differences $w_j - w_i$ are the n^2 wage differentials. An assignment of individuals to occupations (or of occupations to individuals) is an occupation profile. And a wage-occupation (wage-job) profile is a wage profile and an occupation profile. Each individual i has an ordinal preference (utility) function depending on pairs of a wage level w and an occupation j, $u_i(w,j)$. The functions $u_i(w,j)$, as functions of w, are monotone, increasing, and such that for each quadruplet (i,j,k,w) there exists w' such that $u_i(w',j) \geq u_i(w,k)$. Eventually, these functions have a specification of the additive linear form in w, $u^i(w,j) = w - c^i_j$, where c^i_j is the "cost" to individual i of holding occupation j. This cost takes into account all effects of work except the wage compensation received, including any "psychic" and "intangible" effects, any positive and desired effects of occupation (which decrease the cost), and eventually various possible costs of formation.

When we consider the properties of a wage-job profile, we make the three indices coincide, that is, individual i holds job i and receives wage w_i.

Tinbergen-equity is

$$u_i(w_i,i) \geq u_i(w_j,j) \text{ for all } i,j.$$

With linear additive utilities, it is

$$w_i - c^i_i \geq w_j - c^i_j \text{ for all } i,j,$$

which consists in upper and lower bounds on wage differentials

$$c^j_j - c^j_i \leq w_j - w_i \leq c^i_j - c^i_i .$$

The following questions are relevant. Are Tinbergen-equitable wages (wage profiles) possible for a given occupation profile? Are Tinbergen-equitable wage-occupation profiles possible? What is the relation between Tinbergen-equity and the outcome of a free-exchange, competitive market (does the market violate Tinbergen-equity, or does it implement it, does Tinbergen-equity require interfering with the market and forbidding some voluntary exchanges)?

b) Possibility of Tinbergen-equity.

Proposition: Tinbergen-equitable wage-job profiles exist.

This is an application of results from Kaneko (1982,1983), Quinzii (1984) and Gale (1984). The proof is not short (because of the combinatorial structure) and we thus will not adapt it here. Notice that these authors call this result the existence of a "competitive equilibrium" because given the prices (wages) of each assignment (job) no worker prefers another's job to his own (with the corresponding wages). But this in general differs from the free exchange market equilibrium considered below (and by other authors) in which no firm wants and can attract a worker to replace another one with a new wage. If the firm j hiring worker i at wage w wants to maximize $P_j(w,i)$ (for instance its profit), the mentioned results even imply that there exists a wage-job profile which is both Tinbergen-equitable and such that $P_i(w_i,i) \geq P_i(w_j,j)$ for all i,j. The proof consists in showing that Tinbergen-equitable wage profiles exist for any job profile in the core, where the core is defined as the impossibility of a closed chain of job substitutions and new wages which satisfies more all participants (it can be defined only for workers or for workers and employers), and in showing that the core is not empty. Finally, this construction of Tinbergen-equitable wages shows that the same arbitrary constant can be added to all wages without their losing this property. There thus exists Tinbergen-equitable wage-job profiles with positive (or non-negative) wages.

c) Cost minimization.

Proposition. With additive linear utilities, Tinbergen-equitable wage-job profiles minimize total cost; Tinbergen-equitable wages exist if and only if the occupation profile minimizes total cost (hence Tinbergen-equitable wage-job profiles exist).

Cost minimization is defined by $\Sigma c_i^i \leq \Sigma c_{\sigma(i)}^i$ for all permutations σ. This defines a cost-minimizing occupation profile. Tinbergen-equity implies $w_i - c_i^i \geq w_{\sigma(i)} - c_{\sigma(i)}^i$ for all i 's and all permutations σ. By summing for all i for any given σ it implies $\Sigma c_i^i \leq \Sigma c_{\sigma(i)}^i$, the cost-minimization condition. Furthermore, adding the Tinbergen-equity conditions $w_j - w_i \leq c_j^i - c_i^i$ for all closed chains of pairs of indices i,j, shows that these conditions are consistent if and only if $\Sigma c_i^i \leq \Sigma c_{\sigma(i)}^i$ for all permutations σ (some of these permutations leave unchanged some indices, some only permute two indices). Thus Tinbergen-equitable wages exist if and only if the occupation profile minimizes total cost. This proves, with this structure of utilities, that Tinbergen-equitable wage-job profiles exist, and, since the conditions bear only on wage differentials, that such profiles exist with positive (or non-negative) wages.

We naturally say that an occupation profile is cost-equitable when $c_i^i \leq c_j^i$ for all i,j, and that it is cost-adequate when $c_i^i \leq c_i^j$ for all i,j. Cost-equitable or cost-adequate occupation profiles minimize total cost over all occupation profiles. And, by a straightforward adaptation of the results of sections 7, 8 and 9, if there exists one cost-equitable, or one cost-adequate, occupation profile, then all cost-minimizing occupation profiles have this property. Therefore,

Proposition. If cost-equitable, or cost-adequate, occupation profiles exist, then Tinbergen-equity implies this property.

d) Fully defined jobs.

We define a job i by describing with all the required precision and specification all the actions of all types it entails, so that its product in money value can be written as p_i, without having to mention who performs these actions. This product is measured net of non-wage costs to the employer and is assumed not to depend on the other variables (other occupations and wages). The question of the capacities

of the individuals will be considered explicitly in the next sub-sections. We note here that it depends essentially on the specific problem under consideration. In particular it depends on the set of individuals and of jobs considered, and on the analytical treatment of many characteristics, such as education and training, or location, which could be considered either as given or as variables with costs counted within the utility costs c_j^i or paid by the employer who is left with p_i. The employer supplying job i at the wage w earns the profit $p_i - w$. We then have the following results.

Proposition. A wage profile is Tinbergen-equitable if and only if the wage-job profile is a free-exchange market equilibrium.

By definition, the labor market where individual i holds job i for wage w_i, for all i, is in free-exchange equilibrium if there does not exist a pair of a worker i and a job $j \neq i$, and a wage level w, such that both this worker and the profit-seeking employer who supplies job j prefer that worker i takes on job j at wage w. That is, for no triplet (i,j,w) do we have both $u_i(w,j) > u_i(w_i,i)$ and $p_j - w > p_j - w_j$ (that is, $w < w_j$).

If such a triplet (i,j,w) exists, it implies $u_i(w_j,j) > u_i(w_i,i)$ since u_i is increasing in w, and the initial situation thus is not Tinbergen-equitable. And if the situation is not Tinbergen-equitable, there exists at least one pair of different (i,j) such that $u_i(w_j,j) > u_i(w_i,i)$. Then, there exists one $w < w_j$ such that $u_i(w,j) > u_i(w_i,i)$ since u_i is continuous in w, and the situation is not a free-exchange equilibrium of the labor market. Hence the above proposition.

With additive linear utilities, $p_j - c_j^i$ is the "surplus" generated by worker i performing job j. Surplus-maximizing job profiles are the assignments which satisfy $\Sigma(p_i - c_i^i) \geq \Sigma(p_{\sigma(i)} - c_{\sigma(i)}^i)$ for all permutations σ. But this condition is equivalent to $\Sigma c_i^i \leq \Sigma c_{\sigma(i)}^i$. Thus, from a previous result, Tinbergen-equitable wage-occupation profiles maximize total surplus, and Tinbergen-equitable wages exist if and only if the occupation profile maximizes total surplus.

Furthermore, we naturally say that an occupation profile is

surplus-equitable when $p_i - c_i^i \geq p_j - c_j^i$ for all i,j, and surplus-adequate when $p_i - c_i^i \geq p_i - c_i^j$ for all i,j (equivalent to cost-adequation). A wage-occupation profile having any of these two properties maximizes total surplus. It can thus support Tinbergen-equitable wages. And, from previous results, if one occupation profile is surplus-equitable or surplus-adequate, all surplus-maximizing occupation profiles have this property, and all Tinbergen-equitable wage-occupation profiles have this property. That is, if surplus-equity, or surplus-adequacy, is possible, Tinbergen-equity implies this property.

e) Realistic Tinbergen-equity.

The foregoing properties are considered for a given set of individuals and of occupations (for example, it could be in the same social or professional category, or type of job and labor, or industry, or firm, or location, or it could be nation-wide, etc.). In some relevant problems, it may well be that not all individual can perform all jobs (not every individual can be Tinbergen, Ehrenfest, Nozick's Wilt Chamberlain or Mrs Callas). This leads to two possible alternative developments. One consists in restricting the definition of Tinbergen-equity by applying its criterion only to possible pairings of one individual and one job. This leads to the concept of realistic Tinbergen-equity: a wage-occupation profile is defined as being realistically Tinbergen-equitable when, for each i, individual i can hold job i and $u_i(w_i, i) \geq u_i(w_j, j)$ if individual i can hold job j. Tinbergen-equity implies realistic Tinbergen-equity. Thus the existence of realistic Tinbergen-equitable wage-job profiles is implied by that of Tinbergen-equitable ones. And in a free-exchange labor market, only possible worker-occupation pairs can exist. Then, we obtain the following results by a straightforward qualification and replication of the definitions and proofs given above, by restricting the occupation profiles considered to the ones which do not contain an impossible worker-occupation pair (but we assume that at least one job profile is possible). Cost equity, surplus equity and cost and surplus adequacy imply the corresponding "realistic" properties.

Propositions. Realistic Tinbergen-equitable wage-job profiles exist.
A wage profile is realistically Tinbergen-equitable if and only if

the wage-job profile is a free-exchange market equilibrium.

With linear additive utilities,

a realistic Tinbergen-equitable-wage-job profile minimizes total cost and maximizes total surplus over all possible occupation profiles,

if realistic cost equitable, or realistic profit equitable, or realistic cost and profit adequate, occupation profiles can exist, then all realistic Tinbergen-equitable profiles have the corresponding property.

f) Full productivity differentials.

However, the ethical sentiment[25] may require full Tinbergen-equity rather than realistic Tinbergen-equity. Indeed, the deep reason for Tinbergen-equity is to limit the effects on pay discrepancies of causes other than work disutility for the worker (including training in an intertempotal view) --a recurrent theme in the social thought of Tinbergen and of others. And one of these causes is capacities, more specifically society's demand for capacities. We should note, though, that an individual's preference concerning a work which he does not have the capacity to perform (thus which can never be an effective alternative of his choices) is a concept which may raise problems. With full Tinbergen-equity and effective limitations on the individuals'capacities to perform the jobs, the above results do not necessarily hold any more.

Consider however the situation with a more convenient formulation in which individual i holding job j produces p^i_j (net of any cost to the employer other than the individual's wage and independent from wages and from other occupations). $p^i_j=0$ is a possibility[26]. The general result of the existence of Tinbergen-equitable wage-job profiles still holds. Productivity-adequacy is naturally defined by $p^i_i \geq p^j_i$ for all i,j, i.e., each job is attributed to the individual who is the most productive at it (or to one of these individuals).

Proposition. A wage-job profile is a free-exchange market equilibrium if and only if

$$u_i(p^i_j - p^j_j + w_j, j) \leq u_i(w_i, i) \text{ for all } i,j. \qquad (1)$$

Indeed, by definition, if the situation is not a free-exchange

equilibrium there exists a triplet i,j,w, with $i \neq j$, such that $u_i(w,j) > u_i(w_i,i)$ and $p_j^i - w > p_j^j - w_j$, which implies that there exists i,j ($i \neq j$) such that

$$u_i(p_j^i - p_j^j + w_j, j) > u_i(w_i, i). \qquad (2)$$

Thus (1) implies free-exchange equilibrium. And if condition (1) does not hold, relation (2) holds for a pair i,j ($i \neq j$). Then by continuity of u_i there exists a $w < p_j^i - p_j^j + w_j$ satisfying $u_i(w,j) > u_i(w_i,i)$. But the first inequality is $p_j^i - w > p_j^j - w_j$. Hence the situation is not a free exchange equilibrium. Thus free exchange equilibrium implies (1).

Condition (1) provides the relation between Tinbergen-equity and free exchange equilibrium. If $p_j^i \leq p_j^j$ for all i,j, Tinbergen-equity implies free exchange equilibrium. And if $p_j^i \geq p_j^j$ for all i,j, free exchange equilibrium implies Tinbergen-equity.

Proposition. Tinbergen-equity and productivity adequacy imply free exchange equilibrium.

The condition under which free exchange equilibrium implies Tinbergen-equity is more bizarre, since it says that the holder of each job is the least efficient performer of that job. Thus labor market equilibrium may violate Tinbergen-equity. However, with linear additive utilities it still maximizes total surplus, and it is such that a surplus-maximizing occupation profiles can support free exchange equilibrium wages. Indeed, condition (1) becomes

$$p_j^i - p_j^j + w_j - c_j^i \leq w_i - c_i^i$$

or

$$w_j - w_i \leq p_j^j - c_i^i - (p_j^i - c_j^i) \text{ for all } i,j.$$

For any permutation σ, writing $j = \sigma(i)$ and summing these inequalities for all i gives

$$0 \leq \Sigma p_{\sigma(i)}^{\sigma(i)} - \Sigma c_i^i - \Sigma (p_{\sigma(i)}^i - c_{\sigma(i)}^i)$$

or

$$\Sigma (p_i^i - c_i^i) \geq \Sigma (p_{\sigma(i)}^i - c_{\sigma(i)}^i).$$

Conversely, this condition for all σ's guarantees the consistency of the free exchange conditions on wage differentials. And since wages enter the conditions only through these differentials, one can add a same arbitrary constant to all of them, and they can always be positive (or non negative)[27].

g) Wage floors.

When free market wages are not Tinbergen-equitable, a desire for this property may lead to imposing the corresponding limitations on wage differentials. Limitations of the spread of wages for reasons of equity, or for limiting social strife or malaise that feelings of inequity may spurn, is most common within firms or organizations, or through collective bargaining, or sometimes as national policies, and the idea to admit only differences justifiable by the disutility of the various jobs (perhaps including the various costs of training) is among the common notions. Market disequilibria generally result, and in particular involuntary unemployment (we may recall that Keynes views notions and behaviors of workers concerning wage differentials or ratios as the main cause of wage rigidities[28]). Tinbergen-equity submits each wage w_i to the wage floor $w_i \geq \bar{w}_i$ where $\bar{w}_i$ is defined by $u_i(\bar{w}_i, i) = \max_j u_i(w_j, j)$. Let us say that two jobs i and j are equivalent for workers when $u_k(w,i) = u_k(w,j)$, for all workers k and all wage levels w. For these two jobs, Tinbergen-equity implies $u_i(w_i, i) \geq u_i(w_j, j) = u_i(w_j, i)$, and thus $w_i \geq w_j$, and by permuting i and j, $w_j \geq w_i$, and therefore $w_i = w_j$. Consider for example a situation with two categories of jobs, all jobs in one category being equivalent for workers. The "higher" jobs are performed by individuals $i \in H$ with $w_i = w^h$. the "lower" jobs are performed by individuals $i \in L$ with $w_i = w^\ell$. We assume $w^h > w^\ell$. Then Tinbergen-equity restricts the wage differential by $\gamma_1 \leq w^h - w^\ell \leq \gamma_2$. For example, with linear additive utilities and calling $c^i_j = c^i_h$ for $j \in H$ and $c^i_j = c^i_\ell$ for $j \in L$, $\gamma_1 = \max_{i \in H} (c^i_h - c^i_\ell)$ and $\gamma_2 = \min_{i \in L} (c^i_h - c^i_\ell)$. Then, if w_ℓ is given (for example by market equilibrium for lower jobs, or by a horizontal labor supply curve at a minimum wage level --subsistence or other--, or by a minimum wage law), this equity requires a wage floor on the higher wages, $w_h \geq w_\ell + \gamma_1$. Or if w_h is determined in any way, this equity submits the lower wages to the wage floor $w_h \geq w_h - \gamma_2$. The differences in utility due to these two categories of jobs may in particular result from the "higher" labor requiring more effort, or more training or education, than the "lower" one. Of course, other fairness criteria limiting wage discrepancies can have similar effects on wage rigidities and unemployment[29].

h) **Full-payment occupational equity.**

Indeed, Tinbergen-equity is in a sense somewhat extreme (although it describes an opinion which is widespread in some cultures and circles). For instance, the frequent correlation between pay and interest of the job tends to violate it (less so, however, if we take into account the various costs of education, when the better paid and more interesting jobs are those which require more education). The relative extremism of this criterion consists in limiting the explicitly legitimate effect of productivity on the wage to the workers'disutility accompanying this productivity (for instance painful effort, tiring attention, training and education, etc.). Pure talent, or pure correspondence of individual characteristics to the market demand, is not explicitly taken into account (although capacity to produce the painful effort is considered --which shows that this question is not as simple as it may seem). From the famous slogan "to each one according to his work", it retains "to each one according to the disutility of his work" and it disregards "to each one according to the utility of his work to others". On the contrary, both the disutility of work, and the legitimacy of receiving one's productivity benefits are taken into account in the full-payment occupational equity. This criterion is defined when the workers are paid their product, so that individual i in job j receives the wage p_j^i and pure profits are zero. That can for instance result from competition between employers (it could also be an application of the old classical ethical principle of "full payment of the product of labor"). This equity criterion then is

$$u_i(p_i^i, i) \geq u_i(p_j^i, j) \text{ for all } i,j$$

(while Tinbergen-equity with full product wages would be $u_i(p_i^i, i) \geq u_i(p_j^j, j)$ for all i,j).

Then, by definition, each worker does not prefer any other's occupation, and each employer's profit is zero whoever his employee may be. Thus full payment occupational equity implies free exchange equilibrium. Furthermore, it maximizes total surplus with linear additive utilities. Yet, full payment occupational equity may not be possible. However, if the job supply is perfectly elastic in the sense that there is an unlimited supply of jobs of each kind (i.e., jobs having the same effect on individuals'utility and productivity), then

an individual can choose any kind of job whatever the others do, he does not prefer any other individual's job, and free choice of occupation implements full payment occupational equity (this is an example of the equity property of "equality of opportunity").

10 - Conclusion.

The general analysis and the examples proposed above seem to suggest that the structural properties of equity, adequacy and fundamental dominance have a wide scope of relevance, of meaningfulness and of applicability. This is a fortiori the case for the set of these three properties, the interest of which is notably enhanced by the association of two facts: on the one hand, their logical relations of implication, complementarity or extension (the above results), and on the other hand the often wide differences in their meanings (in particular for application to the ethic of distribution) and in their scope of applicability and of existence. Other meaningful properties belonging to the same families, and relations between them, could be added but are left for other papers[30].

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FOOTNOTES

(1) The general and consistent use of criteria by definition rules out casuistry in social choice.Reflective equilibrium rules out intuitionism applied to specific situations, and also to criteria as when one is chosen just for the favorable first impression it makes on us and is then used as an axiom. The multiplicity of criteria interferes with the hope of deriving all judgements from a single all-encompassing simple criterion such as maximizing social utility or welfare (as in utilitarianism or welfarism) or obeying individual freedom (as in Nozick's Anarchy, State and Utopia or in Kolm's Liberal Social Contract), or even from very few criteria (two or three for Rawls). A problem is that these general criteria cannot be applied without other defining and specifying criteria. But the various more specific criteria of rational social choice have smaller and different domains of applicability (of meaningfulness, relevance and decisiveness). They emphasize different aspects. Then the relations between the criteria become an essential point.

(2) Rawls relates the method of reflective equilibrium between theory and intuition to Aristotle (A Theory of Justice, pp.48-51). Indeed, his specific "reflective equilibrium" for choosing principles of justice is but an application of what Plato calls "dialectics" in the Republic (rather than in the Dialogues), which involves consciously systematic "upward ascents" of the mind to basic principles alternating with "descents to conclusion". Moreoverr, our "consistent network of criteria" approach certainly is a part of what Plato calls epistasthai ("rational understanding" rather than just "knowing"). More specifically, this approach is an application of Spinoza's "coherence theory" of "adequate ideas" which matter primarily for their logical relation with each other. This approach is the correct one here (rather than the competing "correspondence" theory of truth as a relation between ideas and reality) because of the nature of the topic --the search for ethical and justice criteria.

(3) As used by Erhenfest, Tinbergen, Foley, Schmeidler, Yaari, Kolm, Varian, Thomson, Baumol and a number of others (see references).

(4) Gale and Shapley (1964), Knuth (1976).

(5) But, we shall see, a society may Pareto-improve its situation by forbidding some marriages (thus implementing an unstable set) along with the relevant transfers.

(6) Unanimity (and thus Pareto-efficiency) needs also to be justified. One possible justification is logical: if all the individuals of society say that A is better than B, then the notion that it is not so cannot exist.

(7) Pareto considers both individual "Bergson" social welfare functions (individual utilities each function of all individuals'"ophélimities") and an ethical social welfare function depending on individual utilities.

(8) Notice that this is the very example with which Tinbergen (and Ehrenfest) introduced this concept in the early forties under the name of "the exchange principle" (see Tinbergen (1953), Pen (1971), Kolm (1971)).

(9) This is also "first order stochastic dominance" (since if these numbers for each state are classified in non-decreasing order the property says that one of these two "curves" is nowhere below the other one), or Suppes' "grading principle". The reason for the adjective "fundamental" will appear below, with the emphasis that this is a relation for ordinal, but inter-individually comparable, utilities.

(10) Early formulations of this "negative" egalitarian principle can be found in Aristotle (Nichomachean Ethics), Hobbes (Leviathan), Locke (Second Treatise in Government), and, not surprisingly, in a particularly clear manner by the co-author of Laplace's "Principle of insufficient reason" for assigning equal probabilities to events for which we have no reason to assign different ones: Condorcet,1789.

(11) This was introduced in Kolm (1973), and elaborated extensively by Thomson (1988).

(12) This is the "justice" property in Kolm, 1971,part III.

(13) Envy and jealousy are different sentiments. Jealousy usually is deeper and affects more the "self". It requires more than the jealous individual can effectively have the place of the individual he is jealous of --thus jealousy is often better grasped by "realistic equity" considered below where the comparison is only for possible reassignments. Relatedly, jealousy is more associated

with competition. The remarks of Goldman and Sussangkarn (1983) would also be both pertinent and debatable (Kolm,1987).

(14) Detailed analysis of such a market is beyond our present topic (see for example Shapley and Shubik (1972), Demange, Gale and Sotomayor (1986)). One relevant result is that it is possible to induce individuals to reveal their true v_j^k in a sealed bid by specifying appropriately the price each will have to pay as a function of the figures announced (see G. Demange (1982), Leonard (1983), G. Demange and D. Gale (1985)).

(15) Apart from the use of fundamental preferences in cases where it is unproblematic or as an undiscussed structure in specific questions, a few economists or other scholars have hinted at, or discussed, or adopted general fundamental preferences for general purposes. These works differ according to the development or existence of a justifying discussion, to the fact that they consider a cardinal utility or an ordinal one (or an ordering), and to their use of this concept which can be positive (explanation of tastes) or normative-ethical. Harsanyi (1955) uses a fundamental cardinal utility, as does Suppes (1966). Tinbergen (1957) discusses the idea that people may be on the "same" indifference locus when some parameter which differs from one to the other is considered as a variable. Kolm (1966,1971) discusses and uses fundamental preference orderings and fundamental ordinal utilities. Rawls (1971)'s hypothetical individuals "in the original position", "behind the veil of ignorance", who are identical and doubtlessly rational (endowed with preference orderings), imply the existence of fundamental preferences, and this author discusses this question more explicitly in Sen and Williams (1982).Hammond (1976)and Arrow (1977) also use explicit ordinal fundamental utilities, the latter with relevant reference to his previous discussions (1963) and with the labelling "co-ordinal" and "co-cardinal" preferences or utilities. Fundamental preferences are also Becker (1976)'s "stable preferences", and they are implicit but, I think, clear, and probably necessary, in Stigler and Becker (1977)'s advocacy of explaining explicitly the differences in tastes among individuals. Roemer (1986) also considers and uses ordinal utility or ordering. All these works except the discussions by Becker and by Stigler and Becker use fundamental preferences for normative or ethical

purpose. It should be noticed that any proposed solution of the general ethical problem of the "good" distribution in society requires bold concepts of one kind or another (and a fundamental preference ordering is definitely less bold than most). An analysis of the mathematical problems which the hypothesis of fundamental preferences raises in the cardinal case is provided in Howe (1985).

(16) Permutations pairing x_j with y_i are for instance impossible if x_j includes the description of a task that individual i does not have the capacity to perform for any reason, or if x_j includes such a description plus an associated wage while individual i 's performance in this job cannot obtain this remuneration from the market. Or the possibility of effectively pairing x_j with y_i may for instance require that individual i and some item in lot x_j be in the same location or exist at the same dates, and if that is not the case assignments including this pairing may be considered impossible. But, also, the possibility that individual i obtains a wage indicated within the description x_j may depend upon the other pairings in the assignment --for instance other individuals can be assigned jobs which are complementary to i 's and heighten i 's productivity, or on the contrary which compete with i 's output and limit his gain from it, or they can, as a result of the assignment, receive incomes which they will choose to spend on i 's products.

(17) It is convenient here to define fundamental dominance as this "weak" fundamental dominance which includes $z \sim z'$ (and such that zfdz).

(18) For instance, one can take $W=\Sigma u(z_i)$ and $w^{\sigma}= \Sigma u^i_{\sigma(i)}$, or $W = \Pi\, u(z_i)$ and $w^{\sigma}= \Pi\, u^i_{\sigma(i)}$.

(19) Fundamental preference enables one to consider "maximin" and "leximin" criteria and orderings, and, obviously, zsfdz' implies leximin preference of z over z'. For given sets of individuals and lots, if one and only one assignment in R is R-equitable, R-adequate or R-fundamentally dominant, leximin classifies it above all other assignments in R (if several assignments in R have this property, any of them is "leximin-better" than or fundamentally equivalent to all other assignments in R).

(20) Fundamental dominance does not exist between two states in particular if both the worst and the best of the 2 n individual situations z_i belong to the same state. For n=2, the only

structures for which fundamental dominance does not allow one to compare the two states z and z' are $z'_1 < z_2 < z_1 < z'_2$ and $z'_1 < z_1 < z_2 < z'_2$ (since the labellings of individuals and of states are irrelevant, and omitting the cases of indifference for simplicity). In these cases, however, it should be noticed that all the ordinally meaningful egalitarian criteria classify z before z'. These criteria are, in order of decreasing ethical defensibility, maximin (and leximin) since $\min_i u(z_i) > \min_i u(z'_i)$, minimal inequality since $|u(z'_2)-u(z'_1)| > |u(z_2)-u(z_1)|$, and minimax (and lexicographic minimax or leximax) since $\max_i u(z_i) < \max_i u(z'_i)$. In the case of any n, Hammond (1976) and Arrow (1977) deduce leximin from a preference of z over z' when, for any two individuals 1 and 2, $z'_1 < z_1 < z_2 < z'_2$, while $z_i \sim z'_i$ for all $i \neq 1,2$ --Pareto-efficiency precludes leximax-- (see also the introduction of leximin in Kolm (1971)).

(21) If, at some stage, there are several best possible marriages in the set where the new choice is to be made (those marriages being for different men and different women), we choose any of them and the following reasonings and results are the same.

(22) Resp. non-increasing.

(23) Notice that the eventual "public good" aspect is confined within pairs and thus does not provide an externality in the usual sense which would be the cause of this inefficiency.

(24) A number of references are gathered in Kolm,1988a.

(25) This expression is better than the usual one "ethical intuition", since the word "intuition" implies the existence of some true fact about which this intuition is.

(26) By defining the fact that individual i holds job j in specifying with sufficient detail all the corresponding actions, one could always have $p^i_j=0$ or $p^i_j=p_j$ independent of i , but that is less interesting.

(27) For brevity we omit in this paper the discussion of eventual constraints on wages such as, in addition to $w_i \geq 0$, non-negative profits $p^i_i - w_i \geq 0$ or $w_i \leq p^i_i$, or $u_i(w_i,i) \geq u_i(0,0)$) where j=0 means that the individual i does not work.

(28) General Theory, chap.2.

(29) A more thorough analysis of such opinions on wages and of their

consequences on employment and for policy consists in considering explicitly preferences on wage differentials or on relative wages and in deducing the corresponding behavior and the "optimal taxation" induced by this non-classical feature (see Kolm,1988a,b,c). The resulting unemployment may not deserve to be called "involuntary" (but the wage may be imposed on individuals by collective action). Other fairness criteria may arise from the very formulation used here. When comparing utilities with permutations involving the three variables of wages, occupations and individuals, Tinbergen-equity is the one which does not require inter-individual comparability of utilities and which allows the most variation otherwise since both jobs and wages vary (together) in the comparisons. If, with linear additive utilities, we use the money value for defining "adequacy", the concept dual to Tinbergen-equity is $w_i - c_i^i \geq w_i - c_i^j$ for all i,j, or $c_i^i \leq c_i^j$ for all i,j or "cost-adequacy" (the holder of each job finds it the least costly). Thus Tinbergen-equitable wages and cost-adequate assignments have the general relations between equity and adequacy presented above. The converse "cost-equity" $c_i^i \leq c_j^i$ for all i,j implies existence of Tinbergen-equitable wages since with it any set of equal wages satisfies Tinbergen-equity. But if we compare utilities inter-individually, there is no reason not to switch all three variables together, that is to adopt the condition $w_i - c_i^i \geq w_j - c_j^j$ for all i,j, or $w_i - w_j = c_i^i - c_j^j$ for all i,j.

(30) For example "minimal equity" and "minimal adequacy" are respectively defined by: for each i there exists $j \neq i$ such that $x_i \underset{i}{\gtrsim} x_j$, or $x_i, y_i \underset{\sim}{\gtrsim} x_i, y_j$. Or fundamental preferences enable one to consider majorities (relative ones for choosing amongst more than two states) between variously permuted states. A number of other properties intervene when the x_i are vectors of quantities of commodities. The concept of adequacy, its relations to equity and the relation of both to fundamental dominance were presented in Kolm (1971), part III, section B and paragraph C.4.g. The properties of fundamental dominance and the other related concepts and relations are in this work and in Kolm (1987).

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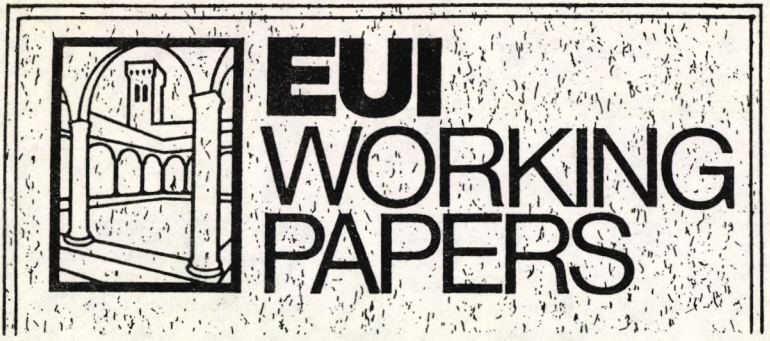

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